FLICKER FUSION MEASUREMENTS AND ANXIETY LEVEL

BY

SANFORD GOLDSTONE

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THE RELATIONSHIP BETWEEN FLICKER FUSION MEASUREMENTS AND ANXIETY LEVEL

by

Sanford Goldstone

Date: April 21, 1953

Approved: Louis D. Cohen, Chairman

Weston LaBarre

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S. G.

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THE RELATIONSHIP BETWEEN FLICKER FUSION MEASUREMENTS AND ANXIETY LEVEL

Chapter I

INTRODUCTION AND STATEMENT OF THE PROBLEM

The need for reliable, quantitative and sensitive measures of personality variables and the promise of sensory threshold determinations for such use prompted the present investigation. One particular need is for measures which are sensitive in time to changes in the level of the variables being considered. The personality variable to be considered in this paper is anxiety and the sensory discrimination procedure is that which provides flicker fusion measurements. In order to study the relationship between anxiety level and flicker fusion measurements, it is essential to specify a measurable meaning for the term anxiety, and utilize criteria which are sufficiently sensitive to provide an ordering within the population being examined.

The population relevant to this investigation involved one group of subjects who manifested complaints associated with the psychiatric syndrome, anxiety reaction, described in the American Psychiatric Association "Diagnostic and Statistical

Manual: Mental Disorders" (1952, p. 32) as follows:

In this kind of reaction the anxiety is diffuse and not restricted to definite situations or objects, as in the case of phobic reactions. It is not controlled by any specific psychological defense mechanism as in other psychoneurotic reactions. This reaction is characterized by anxious expectation and frequently associated with somatic symptomatology. The condition is to be differentiated from normal apprehensiveness or fear. The term is synonymous with the former term anxiety state.

With regard to this clinical use of the term anxiety, Henderson and Gillespie (1947, p. 107) state:

Anxiety as a technical term is a fear of danger usually from within. It may occur either as a continuing state of fear, or more commonly as episodic attacks. The episodes have the well-marked physical manifestations usually associated with fear. It is said that a typical anxiety attack has nothing but somatic symptoms; there is usually, however, a conscious fear, generally of illness but usually undefined.

In limiting the concept anxiety to the above mentioned symptomatic-clinical definition, one must acknowledge other views regarding anxiety. While the anxiety studied in this paper represents overt psychological and physiological signs of discomfort and uneasiness, the concept of anxiety has received increasing attention from students of philosophy, anthropology, psychology, psychoanalysis and neurology in their attempts to deal with personality, learning and cultural phenomena. At the present time limiting the concept of anxiety to the responses associated with the clinical syndrome anxiety reaction is probably the safest approach for utilizing anxiety in research. First, the anxiety responses are operationally specifiable (e.g., nameless fear, palpitation,

shortness of breath, etc.); one may point to them. Secondly, there is considerable agreement by writers upon the responses related to anxiety reaction. On the other hand definitions of anxiety as a function of antecedent conditions (e.g., stress, threat, id-ego conflict, repressed hostility, etc.) provide a dimension of terms not readily operationally specifiable and one observes considerable disagreement among writers as to the significant antecedent conditions to be emphasized. Recently attempts have been made to bring order to the study of anxiety by assessing disagreements and common elements in the various approaches in order to provide common ground for further inquiry (Hoch and Zubin 1950, May 1950). Whether or not the various writers on anxiety are talking about the same thing is for future research to decide (Underwood 1953). In order to avoid the confusion inherent in the use of a term with many possible meanings, this writer will henceforth refer to anxiety as the above described clinical syndrome.

In selecting a sensory threshold technique which might distinguish between subjects with high and low anxiety or reflect change within subjects with high anxiety, the following criteria are relevant:

1. A method which is sufficiently sensitive as to show limited change.
2. A method capable of providing quantitative differentiation.
3. A method which is reliable.
4. A method that has been sufficiently studied such that

the relevant variables have been pointed out.

In studies to be described shortly it has been shown that anxious subjects show impairment in sensory discrimination ability. These findings suggested the possibility of using flicker fusion measurements for this investigation. Repeated stimulation of the retina by successive flashes of light is sometimes seen as a flicker and is sometimes seen as steady, depending upon the flash frequency. Each flash has two phases, light and dark, and is called a cycle. The number of cycles-per-second (CPS)[1] necessary to produce what is seen as a steady light is called flicker fusion threshold (FFT).[2]

Hilgard et al. (1951, p. 98) utilizing a conditioning procedure concluded: ". . . more anxious subjects would not discriminate as well as less anxious ones." Krugman (1947) in an exploratory investigation utilizing FFT found that the mean score made by a normal group was higher than that made by an anxiety reaction group; the normal group being more sensitive to flicker than the anxiety reaction group. He goes on to say:

Flicker fusion frequency is a rather easily measured, almost physiological function and its relationship with other types

---

[1] Cycles-per-second is referred to hereafter as CPS.

[2] Flicker fusion threshold is referred to hereafter as FFT. FFT is comparable to FFF (fusion frequency of flicker), CFF (critical fusion frequency) and FFI (flicker fusion intensity).

relationship between anxiety level and FFT.

It is the purpose of this investigation to clarify empirically the relationship between flicker fusion measurements and anxiety level in a controlled study eliminating some of the sources of doubt existing in previous related experimentation and employing better controls over the physical conditions.

The following paper describes in detail previous related work, the design of the experiment, the results, and an evaluation of these findings.

Chapter II

BACKGROUND ON THE APPLICATION OF THE FLICKER TECHNIQUE

The following chapter will provide an intensive review and evaluation of the literature on flicker fusion relevant to the investigation described in this paper.

The phenomenon of fusion has a long history which has been reviewed by several writers (Bartley 1941, Berg 1949, Hecht 1938, Landis 1951, Lythgoe and Tansley 1929). The most primitive investigations date back as far as 150 A.D. From the middle of the eighteenth century until recently the numerous investigations related to flicker fusion have concerned themselves primarily with the method of determining FFT, the visual physiology involved in the phenomenon, the development of laws relating experimental conditions to FFT and the utilization of FFT studies to provide theoretical formulations for the psychology and physiology of vision. From this earlier work, reviewed by Bartley (1941), one is able to evaluate on the influence of the many experimental variables involved in a

flicker fusion study (e.g., intensity of light, light:dark ratio, etc.) and design an experiment accordingly. These variables will be discussed in Appendix A.

One has only to survey the literature on flicker fusion to recognize the intense present interest in this method as a clinical tool. In 1903 Braunstein undertook to diagnose various eye conditions such as optic atrophy, retinitis, glaucoma, hemeralopia and amblyopia ex anopsia by determining FFT. Although his findings were positive, his work was apparently premature and very few similar studies appeared during the following thirty years. In the nineteen thirties one finds several studies (Phillips 1933, Riddell 1936) utilizing the flicker fusion technique to study visual field defects as indices of intracranial tumor. The nineteen forties saw a progressive increase in the number of publications on flicker fusion. The continuation of this trend in addition to the wide variety of purposes served by this method at present, indicate the establishment of the flicker fusion technique as a tool for clinical research and diagnosis.

The remainder of this chapter will provide a review of the most pertinent research which applied the flicker fusion technique, focusing the reader's attention upon the kinds of problems studied, the methods of utilizing the flicker procedure, the nature of the results obtained, the quantitative sensitivity of the flicker measure and the implications of the research with regard to the meaning of the FFT.

The recent research utilizing the flicker technique may

be divided, for the purpose of clarity of exposition, into the following categories:

1. Studies of the relationship between FFT and normal physiological states or processes (fatigue, age and sex).
2. Studies of the relationship between FFT and experimentally induced imbalance (pharmacological studies, anoxia studies, etc.).
3. Studies of the relationship between FFT and pathological physiological states or processes (central nervous system pathology, ophthalmologic pathology, etc.).
4. Studies of the relationship between FFT and psychiatric disorders (psychosis, anxiety, etc.).

The above categories do not classify exclusively all research in this area. In many instances overlap is noted, such that one study may fall into several of the aforementioned categories. Thus in reviewing the literature relevant to these four areas, one may find a single publication referred to more than once.

Before going into the work involved in the four categories it might be wise, in order to avoid confusion, to remind the reader that, contrary to other areas of psychophysical research, high threshold for fusion indicates high sensitivity to flicker and low threshold for fusion indicates low sensitivity to flicker.

1. Studies of the Relationship between FFT and Normal Physiological States or Processes

Fatigue. None of the areas of study to be discussed have received as much attention as the relationship of FFT and fatigue (Adler et al. 1950, Brozek and Keys 1944a and b, Enzer et al. 1941, 1942, Graybeil et al. 1943, Lee 1940, Miles 1950a, Scow et al. 1950, Simonson and Enzer 1941, 1942, Simonson et al. 1941a and c, 1942, Snell 1933, Tylor 1947). Many varieties of fatigue conditions have been investigated, including fatigue usually associated with: normal mental work (Simonson and Enzer 1941), normal physical work (Graybeil et al. 1943, Lee 1940), induced physical work (Brozek and Keys 1944 a and b), hypoxia (Scow et al. 1950), vitamin B deficiency (Simonson et al. 1942), hypothyroidism (Enzer et al. 1941), circulatory insufficiency (Enzer et al. 1942), castration (Simonson et al. 1941c) and prolonged wakefulness (Tylor 1947). In all these studies except that by Tylor, fatigue, defined in terms of subjective feeling and impairment in work output, was accompanied by a decreased FFT. When drugs which reduce a sense of fatigue, such as amphetamine, caffeine, or pervitin, are administered, an increase in FFT is noted concomitant with a reduction in subjective fatigue. This increase in FFT paralleling a reduction in fatigue was also observed upon vitamin B and testosterone therapy where an initial deficiency existed. Snell (1933) demonstrated flicker fatigue. He showed that exposure to flickering light for one half hour produced a decrease in FFT of as much as 12 CPS. Exposure to a steady

light for the same length of time did not decrease the FFT. A similar finding was reported by Kubis and Buckley (1949).

Thus in spite of the ambiguity of the term fatigue emphasized by Bartley and Chute (1947) and Carmichael and Dearborn (1947), one must conclude from the evidence cited that subjective and experimental fatigue are reflected in FFT.

Age. Studies of the relationship between FFT and age have covered the age range from five to eighty years. Several writers (Hartmann 1934, Meili and Tobler 1931) failed to observe any relationship in studies involving a limited number of subjects and narrow age ranges. More recent intensive investigations (Brozek and Keys 1945, Misiak 1947, 1948b, 1951, Simonson et al. 1941b) utilizing a large number of subjects and a greater range in age groups examined, consistently report a progressive decline in FFT with age. These results have been verified by observations of other workers (Berg 1949, Erlick and Landis 1952, Weekers and Roussel 1946, 1948a). Weekers and Roussel (1948a) attribute this decline in FFT to sclerosis of the iris and from consequent changes in the pupil. Misiak (1951) reports that this decreased FFT with age does not become a significant variable until the age of fifty five.

Sex. Two studies (Hartmann 1934, Miller 1942) suggested a higher FFT in males. A recent intensive investigation (Misiak 1947) revealed no sex differences.

2. Studies of the Relationship between FFT and Experimentally Induced Imbalance

Oxygen deprivation. Several writers (Lilienthal and Fugitt 1945, Scow et al. 1950) have reported a significant reduction in FFT as a result of being subjected to a low pressure chamber equivalent to an altitude of ten to eighteen thousand feet. Others (Forssman 1946, Sjöstrand 1942a and b) observed the same phenomenon as a result of exposure to excess carbon monoxide. Gellhorn and Hailman (1943) found parallel changes in FFT and EEG during anoxia. Keighley et al. (1951) studied the effects of positive acceleration in subjects exposed to a human centrifuge upon FFT. The pooling of blood in the lower part of the body and failure in circulation of the upper part apparently resulted in a depression of FFT.

Exposure to five percent carbon dioxide. Simonson and Winchell (1951) found a decline in FFT as a result of exposure to a five percent carbon dioxide, ninety five percent oxygen mixture. From their findings they concluded that carbon dioxide has a central nervous system depressing effect as well as being a respiratory stimulant.

Drugs. Seitz and Rosenthal (1940) showed that local application of strychnine to one eye counteracts the effects of anoxia without interfering with the action of anoxia on the other eye. Thus they observed that the strychnine treated eye

regained normal FFT and normal angioscotomata during anoxia while the untreated eye showed the characteristic decline in FFT and an enlargement of the angioscotomata.

The effect of central nervous system depressants (e.g., seconal, phenobarbital, etc.) upon FFT was studied by Roback et al. (1952) and Landis and Zubin (1951). They observed a reduction in FFT. A similar effect was demonstrated with antihistaminics (Roback et al. 1952). Alcohol was found (Goldberg 1943) to depress FFT. Since a greater concentration of alcohol was necessary in heavy drinkers to produce the same depression in FFT found in abstainers, Goldberg concluded that the habituation to alcohol increased the tolerance of the central nervous system. This was the first use of the flicker method in a tolerance test.

Dexedrine, amphetamine and caffeine were demonstrated to increase FFT (Adler et al. 1941, Simonson and Enzer 1942, Simonson et al. 1941 a, Roback et al. 1952). Cigarette consumption was also found to elevate FFT (Larson et al. 1950). Roback et al. (1952) utilized the flicker method to study the effect of analeptic drugs (caffeine, dexedrine and amphetamine) on the somnifacient effect of seconal. Through the FFT they were able to determine the relative efficiency, and necessary dosage of the analeptic drugs in counteracting the effect of central nervous system depressants. To quote Roback et al. (1952, p. 566): "It becomes apparent that the measurement of FFT is a tool for the study of the effects of various agents acting directly or indirectly on the central nervous system,

especially the visual mechanism."

Administration of methyltestosterone (Simonson et al. 1941c) and vitamin B (Simonson et al. 1942) in cases of deficiency raised the FFT, indicating the usefulness of FFT as an indicator of change as a result of therapy.

Recently a series of important studies involving drugs and pointing out the diagnostic sensitivity of the flicker test have come to light. Berg (1949) utilized the flicker method as an index of response to evipan in an investigation of central nervous system pathology. Krasno and Ivy (1950) used FFT as an index of response to nitroglycerine in an investigation of cardiovascular disease. An extension of the latter work (Brill et al. 1951, Marty and Hardy 1952) related the nitroglycerine-flicker test to toxemia in pregnancy. These studies and their implications will be discussed in the section of this chapter devoted to central nervous system pathology and cardiovascular disease.

3. Studies of the Relationship between FFT and Pathological Physiological States or Processes

Ophthalmologic pathology. In 1903 Braunstein undertook to diagnose various eye conditions such as optic atrophy, retinitis, detachment of the retina, glaucoma, hemeralopia and amblyopia ex anopsia by determining foveal FFT with the light reflected from white and colored sectors of discs. The general results found were that the FFT of pathologically

changed eyes was depressed and this decline was more noticeable the more severe the condition. In 1908 Lohmann demonstrated in cases of congenital amblyopia that FFT was increased centrally. This finding was subsequently verified by Miles (1949) and Teraskeli (1934). The work of Phillips (1933), Enroth and Werner (1935) and Riddell (1936) indicated the value of more complete flicker fusion fields. Several studies of differences in sensitivity to flicker of various regions of the retina were originally accomplished (Creed and Ruch 1932, Cooper et al. 1933, Granit 1930, Granit and Harper 1930, Hecht and Verrijp 1933, Ross 1936) independent of clinical considerations. More recently in ophthalmological circles, attention has been focused upon the utilization of the flicker method in visual field determinations for diagnostic purposes (Hylkema 1942a and b, Lebensohn 1950, Mayer and Sherman 1938, Miles 1950a and b, 1951, Niederhoff 1936, Weekers and Roussel 1946, 1948a). Miles (1950b, p. 1069) indicates that flicker perimetry is superior to the traditional perimetric methods of evaluating visual fields because it is less affected by ". . . poor acuity, refractive blur, peripheral aberrations and low peripheral acuity, translucent defects of ocular medias, suppression amblopia, reduced intelligence and attention." Hylkema (1942, p. 182) observed: "The fusion frequency with intermittent light provides the best method by which to determine the function at any point of the visual field and to express it as a figure."

Flicker fusion fields has been found a sensitive indicator

of defect in cases with detached retina (Weekers and Roussel 1948b) and glaucoma (Hylkema 1943a and b, Miles 1950c, Weekers et al. 1949) where early diagnosis is important for surgical recovery. FFT also proved useful diagnostically and prognostically in cases with cataracts (Hylkema 1943a and b, Weekers and Roussel 1948a), and tobacco intoxication (Roussel and Weekers 1947). In all instances the area of defect is characterized by a depression of FFT. The one exception to this is amblyopia ex anopsia (Lohmann 1908, Miles 1949, Teraskeli (1934) where an elevation of central FFT was observed.

Central nervous system pathology. Visual field evaluation is of considerable importance in the investigation of central nervous system pathology, particularly the diagnosis of space occupying lesions. Weekers and Roussel (1948a, p. 190) state:

> The measurement of frequency of fusion supplements usefully perimetric studies in lesions of the intracranial optic pathways. Whilst perimetry delineates the defect, frequency of fusion serves to determine its density. When a scotoma is small and dense, perimetry is a method of choice; where the defects are extensive and light, measurements of frequency of fusion gives the fuller information.

Phillips (1933) was the first to study flicker fusion field defects as indices of intracranial lesions. He found that in cases of intracranial lesions of the optic pathways, flicker fusion values were affected earlier and recovered more quickly than form perception. Riddell (1936) accomplished a follow-up study designed to evaluate the findings of Phillips. He demonstrated agreement between perimetry and flicker measurements in cases of intracranial tumor but concluded that

the flicker technique would find greater application in optical work.

Werner and Thuma (1940) compared FFT of feebleminded children with a history of birth injury with the FFT of feebleminded children with no such history and found a significantly lower threshold in the former group. Enzer et al. (1944) observed a second and third reappearance of flicker at 105 CPS and 125 CPS which resulted as an interference phenomenon between waves of luminosity of the filament, produced by the cycles of an alternating current. An investigation demonstrated an impairment in the recognition of the second and third flickers in patients with brain pathology. Halstead (1947a and b) reported a reliably lower FFT in frontal lobectomy subjects as compared with normal and nonfrontal lobectomy subjects. In addition he observed a significantly lower intraindividual variability in the frontal lobectomy group than in the other two groups, indicating that the frontal lobectomy subject is more accurate in his judgments regarding his fusion point than the normal or nonfrontal lobectomy subject, although they fuse at relatively lower values in comparison with either. A follow-up study by Young (1949) found a similar trend with regard to reduced FFT after lobectomy, although her differences were not as marked as those of Halstead. Teuber and Bender (1948a and b) reported a lower FFT in subjects with penetrating wounds of the occiput as compared with normal subjects. Battersby (1951) compared the regional gradient of FFT in patients with frontal or occipital injury. Only those patients with occipital

damage revealed impairment of the flicker fusion fields.

In a recent monograph Berg (1949) reported a study which represents a marked contribution to the use of the flicker technique as a diagnostic aid in central nervous system pathology. In this investigation intensity of light was varied in order to obtain a fusion point, rather than frequency variation. Expressing the view that the flicker test might be regarded as a functional test for large parts of the central nervous system, Berg studied the flicker fusion response to ten percent of a narcotic dose of the central nervous system depressant, evipan. An FFT value was obtained before and after the ingestion of the narcotic. He found a depressed flicker fusion intensity[1] (positive test) after evipan in 124 of 129 cases of central nervous system pathology. In no control subject (no central nervous system involvement) did this reduction in sensitivity after evipan occur. Clinical improvement was accompanied by a negative evipan-flicker test (no decline after the drug).

This procedure represents a considerable advancement in the use of the flicker technique as a research tool and diagnostic aid. It indicates the establishment of this procedure as an index of change beyond the retinal level and thus permits its

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[1] In this study flicker fusion intensity was used instead of flicker fusion frequency but the meaning of a depressed or elevated score remains the same. A decreased flicker fusion intensity indicates a reduced sensitivity to flicker.

use in a more complex test situation.

Cardiovascular function. The status of the eye, particularly that of the vascular bed of the retina is of considerable importance in the diagnosis of cardiovascular disease. Recently the flicker test has been shown to have considerable sensitivity to cardiovascular disease and change in the condition of the retinal blood vessels. Enzer et al. 1942 demonstrated a depressed FFT in patients with circulatory insufficiency from heart disease and hypertension. The primary concern of these investigators, however, was with the fatigue associated with circulatory insufficiency. In 1950, Krasno and Ivy, like Berg (1949), used the flicker fusion method as the index of response to a drug, in order to demonstrate a procedure for the early diagnosis of, and evaluation of the medication in cardiovascular disease. Their preinvestigation reasoning went as follows: Gross anatomic changes occur in the retinal blood vessels in hypertensive cardiovascular disease and these anatomic changes are preceded by a physiologic hypertonus or spasm of the arterioles. If this be true, then nitroglycerine and other vasodilators should abolish the hypertonus or spasm of the arterioles of the retina and by an active hyperemia improve the oxygen supply of the retina which would elevate the FFT. On the other hand, if the arterioles of the retina and visual pathways are normal, nitroglycerine would dilate the arterioles resulting in passive congestion of the retina and depress the FFT. In view of the intimacy of the embryologic development of the vasomotor supply of the heart and retina,

the detection of a vasospastic tendency in the retina might reflect a similar tendency in the coronary arterioles. In general then, these writers attempted to:

> . . . ascertain whether the detection of the vasospastic tendency in the retinal vessels might be correlated with a vasospastic tendency or arterial vascular disease elsewhere in the body. This hypothesis regarding hypertension is supported by the vascular changes found by ophthalmologic examination of the retina. (p. 1270)

Ninety nine percent of the two hundred and sixteen cardiovascular patients examined manifested an elevation in FFT following oral administration of nitroglycerine. Of the control patients who had no clinical signs of cardiovascular disease, 206 showed no change or a depression in FFT and 62 revealed the "abnormal" elevation. Thirty two of these sixty two returned to the "normal" depression of FFT following general hygiene therapy plus papaverine. Two of the control subjects who had a normal resting EKG and blood pressure but who manifested an "abnormal" nitroglycerine-flicker test developed a clinically obvious coronary occlusion in a few months. Thus in addition to providing a diagnostic aid in clinically evident cardiovascular disease, the sensitivity of the nitroglycerine-flicker test might prove useful in preclinical diagnosis. The authors also suggest that this technique might have value in ascertaining whether an alleged vasodilator drug is actually counteracting a vasospastic condition.

In the Arctic Hopkins (1952) found more abnormal nitroglycerine-flicker tests in subjects without evident cariovascular disease than were reported by Krasno and Ivy (1950) for temperate

climates. This was taken as an indicator of the contribution of temperature as a variable in this test although the possibility of preclinical disposition to cardiovascular disease in those manifesting the elevated FFT after nitroglycerine, was not discounted.

An extension of the nitroglycerine-flicker test as an aid in the preclinical recognition and therapy of toxemia in pregnancy has recently been revealed (Brill et al. 1951, Marty and Hardy 1952). Since vasospasm is an integral part of the general picture of toxemia in pregnancy, it was believed that the Krasno-Ivy technique might prove a sensitive test of toxemia before it became manifest clinically. In the most recent study a false positive of fourteen percent and a false negative of 3.3 percent was noted after follow-up of one hundred and eighteen patients tested in early pregnancy when no toxemia was evident. The nitroglycerine-flicker test is now commercially available as a clinical tool. In addition to its diagnostic function, the flicker test furnishes information as to the relative effectiveness of various drugs and dosages in relieving vasospasm.

Endocrine disorders. A reduced FFT was noted in patients with hypothyroidism (Enzer et al. 1941) and in eunuchoids and castrates (Simonson et al. 1941).

4. Studies of the Relationship Between FFT and Psychiatric Disorders

Less consideration has been given to the relationship between FFT and psychiatric disorders by workers than given the more specifically physiological categories already discussed. Riddell (1936) predicted the possible utility of the flicker method in the study of the psychoneuroses. Krugman (1947) suggested a lower FFT in subjects with an anxiety reaction as compared with normal subjects. Riccuiti (1949) compared the FFT in psychotic, psychoneurotic and normal subjects with a slight difference observed only between a manic and normal group. The FFT of the manic group was slightly depressed. Incidental observations of anxiety within the test situation failed to verify the findings of Krugman.

In view of the fruitful research utilizing the flicker method in other areas of clinical research and diagnosis, it would appear desirable to clarify the relationship between flicker fusion measurements and psychological or psychiatric factors.

What Does the FFT Tell Us?

In summary it has been shown that the ability to perceive a flickering light is a sensitive index of fatigue; of oxygen deprivation whether induced by circulatory insufficiency, anoxia or pharmacologically; of change as a function of central and autonomic nervous system stimulants and depressants; of

ophthalmologic pathology in any part of the visual pathway; of central nervous system pathology; of cardiovascular function and possibly of anxiety. FFT has been found sensitive enough to reflect changes as a result of therapy or spontaneous improvement where chronic fatigue, hypoxia, and ophthalmologic, central nervous system and cardiovascular pathology were involved. FFT has been used for determining the comparative efficiency of certain drugs and dosages in counteracting various physiological conditions.

In neurophysiology, the rapidity with which a nerve can respond to a rapid succession of stimuli has long been used as an index of its functional capacity (Hopkins 1952). Such a rapid succession of stimuli is provided by a flickering light. To quote Bartley and Chute (1947, p. 161):

> This fusion property of the visual mechanism has been used in experimentation to test physiological state or function, the presumption being that a neural system that can respond to the high rates of intermittency by an intermittency of its own is functionally better than one that responds by continuity. . . . The higher the CFF the better the functional state usually is assumed to be.

This leads to the question: What is functionally better? Traditionally the phenomenon of fusion has been considered as peripherally determined with the retina as the limiting factor. One has only to survey the early research on flicker (reviewed by Bartley 1951) to become aware of the emphasis placed upon the retina and its anatomic and photochemical constitution. In recent years with research indicating the relationship between FFT and factors not directly visual or retinal, emphasis

has shifted to the central factors involved in FFT.

It has been found by several writers that FFT and the alpha rhythm of brain wave activity are intimately related. When the eye is subjected to intermittent stimulation, it is possible to "drive" or increase the occipital alpha beyond its normal frequency in a manner closely corresponding to the changes in frequency of the intermittent light (Adrian and Mathews 1934, Halstead et al. 1942, Toman 1941). Walker et al. (1943) found it possible to "drive" the electrical activity of the visual structures below the cortex (optico-geniculo-striate system) to frequencies above the animal's FFT, while it was not possible to "drive" the activity of the cortical visual areas above FFT. These observations were interpreted as evidence eliminating the retina as a limiting factor on the temporal resolving power of the visual system, and indicating that fusion is a cortical phenomenon. These findings suggest encouragingly the possibility of using the performance on sensory discrimination tasks as indices of physiological states or behavior variables involving the whole organism.

An emphasis upon the central nervous system in the interpreting of flicker fusion data pervades the writings of recent and contemporary authors. They base their central emphasis upon the EEG, and the effect of physical and mental fatigue, central nervous system pathology and drug studies involving the central nervous system. The statement of Berg (1949, p. 17) that ". . . flicker fusion may be regarded as a functional test

for large parts of the central nervous system." adequately characterizes the viewpoint of many investigators (Goldberg 1943, Halstead 1947a, Larson 1950, Roback et al. 1952, Simonson et al. 1941c, Simonson and Winchell 1951).

The conception of the flicker fusion phenomenon as either central (Halstead 1947a) or peripheral (Hecht 1938) is not a fruitful distinction. It has been shown in this chapter that many direct and indirect influences upon any component of the visual mechanism is reflected in the FFT; retinal pathology of a neural or circulatory nature and cerebral pathology or pharmacological influence. At this stage of knowledge the FFT probably should be regarded as an index of the functional[2] state of the retino-cortical system. In some instances one might be able to specify the locus of impairment in the retino-cortical system. Thus one can refer to the vascular bed of the retina in toxemia of pregnancy or a part of the cortex in a case of specified brain injury. However at the present time in more vaguely defined disorders such as anxiety reaction it is not possible to specify that component of the retino-cortical system which might be involved in FFT changes.

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[2]The higher the number of impulses a nervous center can preserve (afferent function) or emit (efferent function) per unit of time the better is its functional state assumed to be.

Chapter III

METHODS

The following chapter will present in detail an account of: 1. The flicker fusion method including a discussion of (a) the apparatus, (b) procedure for administering the flicker test and (c) techniques for analyzing flicker fusion data; 2. The anxiety level criteria; 3. The selection of subjects and groups; 4. The order of test administration.

1. The Flicker Fusion Method

Apparatus used in this investigation. The FFT is affected by several experimental variables which have been studied rather extensively in the past. Much of this work has been summarized by Bartley (1941) and Granit (1936) who have been referred to as sources by many investigators. A discussion of these experimental variables (e.g., intensity of light, light: dark ratio, adaptation, etc.) with particular emphasis upon their relationship to the present investigation may be found

in Appendix A.

Most of the early investigations of flicker fusion utilized a rotating disk which interrupted a beam of light. More recently electronic instruments have been developed to obtain more adequate control over the physical conditions in an FFT determination (Henry 1942, Ireland 1950b, Fritze and Simonson 1951, Mayer and Sherman 1938).

A 5 mm. (diameter) test patch was used. It was mounted at eye level 30.5 cm. from the subject's eyes to insure foveal fixation. The patch appeared white under the conditions used. The patch was mounted in a black box (10" x 10" x 18") providing a uniform surround of very low illumination.[1] Binocular fixation was employed and control of the head position was obtained by the use of a chin rest. The examination room, which measured 9' x 9' x 9', was kept dimly illuminated by a 60-watt mazda lamp mounted in a far corner of the room, and a frosted night light for the examiner in order to clearly illuminate the controls.[1]

The light source was a Silvania Electric Company (R1131A) glow modulator tube illuminating a milk glass screen. The tube was activated by an electronic unit (see Appendix B for complete details on this unit, including circuit and block diagrams) which provided an input to the lamp of essentially square wave

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[1] We were unable to accurately measure the very low level of illumination of the surroundings with the instruments available.

form.[2] In this experiment the brightness of the patch was 0.35 millilamberts. Flicker rates were variable between 18-60 CPS. The light:dark ratio used was 60:40 over the whole range. A constant intertrial interval, controlled by the unit, was one and one half seconds. The apparatus was calibrated by means of a cathode ray oscilloscope and flicker rates were reliable within a half a cycle. Calibration during the course of the experiment was provided by a neon zero set.

Administration. The subject was asked to seat himself in front of the flicker apparatus. The lights were dimmed and the subject was asked to relax for three minutes to allow for some measure of adaptation to the new conditions of illumination. Following this, the subject was told to fit his head on the chin rest as comfortably as possible. A light oscillating at 60 CPS was presented with the following instructions: "You now see a spot of white light in front of you. I want you to concentrate your attention on this light at all times. Be sure that you are always looking straight ahead at the light. Is this light flickering or is it steady?"

The subject responded and the 60 cycle light was turned off and replaced by a 20 CPS flickering light. The subject was asked: "Is this light flickering or is it steady?"

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[2]The invaluable aid of Mr. Arthur Foster, technical consultant for the Department of Psychiatry, is gratefully acknowledged. Mr. Foster designed and built the flicker fusion electronic unit and provided many valuable suggestions regarding the implimenting of this investigation.

After the subject responded he was informed as follows: "You have the idea and I will now show you a series of lights. You tell me if the light you see is flickering or if it is steady. Remember, concentrate your attention on the light spot at all times."

A method of limits method of stimulus presentation was used. Alternating runs of ascending and descending flicker rates were presented. The step interval was 0.5 CPS. Each ascending run was terminated when the subject reported fusion three consecutive times. Each descending run was terminated when the subject reported flicker three consecutive times. Each run was initiated at a frequency rate two steps (1.0 CPS) above or below the value terminating the preceding run, depending upon whether it was an ascending or descending run.

An initial series of four runs were given to the subject in order to determine approximately his threshold range and to familiarize him with the task. Following this an alternating series of five ascending and five descending runs were given for practice. After a thirty second rest the experimental series were introduced. Two blocks of five ascending alternating with five descending runs each were used, separated by a thirty second rest period.

The data were treated in the following fashion: The percentage of reports of fusion for each frequency was determined. These values were then plotted on normal probability paper (Dixon and Massey 1951) on the assumption that these values were normally distributed, and a straight line was visually

fitted. Two derived measures were obtained from these plots. The first was the FFT which was defined as the frequency at which the subject reported flicker fifty percent of the time. This was considered to be a measure of the sensitivity of the subject. The second was a measure of the slope of the curve defined as the difference between the frequency producing fifty percent reports of flicker and the frequency producing sixteen percent reports of flicker. This value is the standard deviation of the distribution and is considered to be a measure of the spread or precision of the judgments of flicker.

A summary of the administration of the flicker test and the scoring procedure may be had by referring to the sample data sheet and probability graph found in Appendix C.

2. Anxiety Criteria

In view of the difficulty of assessing anxiety level objectively, it was felt that two independent criteria should be utilized in order to increase the validity of patient selection. If two indices of different origin and nature could be shown to agree on the selection of a subject for either a high or low anxiety group, one might feel more secure in the classification. The two methods chosen involve two approaches to the measurement of the anxiety syndrome. One depends upon the rating of an examiner and the other upon the patient's judgments concerning his own condition.

The examiner's rating (A1).[3] Rating scales developed by Lorr (1952) to evaluate an anxiety-tension cluster were used. They included five rating scales; tension, irritability, anxiety and frustration tolerance rated on a six point scale and sleep complaints on a four point scale. For a sample copy of the scales, see Appendix D.

If the highest number on each scale indicates the most disturbance, then a sum of twenty eight would indicate the highest level of anxiety and a sum of five would indicate the lowest level of anxiety. The index of anxiety level we used was expressed as an average by dividing the sum of the ratings by the number of scales (five). Thus a score of 5.6 on A1 would refer to the highest obtainable anxiety rating and a score of 1.0 on A1 would refer to the lowest obtainable anxiety rating. Based on preliminary observation of twenty subjects it was decided that a score of 3.2 or more should place a subject in the high anxiety group and a score of 3.0 or less should place a subject in the low anxiety group. Although selection of subjects from the extremes of A1 would probably result in sharper differentiation of anxiety level, practical limitations related to the availability of comparatively small numbers of subjects eliminated this procedure. It was hoped that by using two measures of anxiety which must agree, one might eliminate the borderline subjects.

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[3]Hereafter the Lorr ratings will be referred to as A1.

Complaint check list (A2).[4] A psychiatric complaint check list in the process of development at Duke Hospital for the purpose of evaluating symptomatic change as a result of psychiatric therapy, was utilized as a second criterion of anxiety level. This check list consists of one hundred and eleven statements of which twenty three constitute those complaints considered relevant to an anxiety reaction. A copy of the check list in addition to detailed information concerning the development of the check list may be found in Appendix E.

The one hundred and eleven complaints were placed upon individual cards. The subject was instructed as follows: "Read each card carefully and decide whether the statement on it applies to you or not. Do this with all the cards in front of you until they have been separated into two piles, those that apply to you and those that do not."

The anxiety score was the sum total of anxiety items chosen as applying to the subject out of the twenty three possible anxiety cards. It was decided on the basis of preliminary observations on twenty subjects to assign all subjects with seven anxiety complaints or less to a low anxiety group and those with eight or more to a high anxiety group. As stated with regard to the rating procedure (A1), the limited number of subjects available made it impossible to employ the more desirable extremes method. It would appear that any significant

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[4]Hereafter the check list will be referred to as A2.

differences found using the cut-off point method would be more dramatically exposed using the method of extremes for selection of groups.

3. The Selection of Subjects and Groups

Patients. Serial admissions to the outpatient psychiatric clinic at Duke Hospital from October, 1952 through January, 1953 and all of the patients who were already in psychotherapy at the clinic, and who met the following criteria were selected: 1. Age: 17-50; 2. Race: white; 3. Sex: either; 4. Education: literate; 5. No demonstrated or suspected central nervous system pathology; 6. No demonstrated or suspected gross ophthalmologic pathology such as glaucoma, detached retina, cataracts, etc.; 7. No severe psychosis which could result in doubt regarding the validity of the testing procedures; 8. Not under treatment by any medication known to result in FFT alteration such as narcotics, stimulants, and endocrine preparations; 9. No alcohol consumption for twenty four hours; 10. Practical considerations made it impossible to control cigarette consumption which is known to influence FFT. However it was noted in the data by Larson et al. (1950) that the residual effects of smoking on FFT after fifteen minutes of abstinance was negligable. No subject in this experiment engaged in smoking for at least one half hour prior to the flicker test; 11. Fatigue: Although it was not possible to control this factor due to varying lengths of travel necessary to reach the

clinic, no subject reported excessive activity immediately prior to arriving at the clinic. The tests were performed, whenever possible, in the morning or early afternoon. None of the clinic activities prior to the flicker test might be regarded as physically fatiguing.

Controls. In order to secure comparatively homogeneous groups, the normal subjects were chosen from the relatives and friends who accompanied the patients to the clinic. These subjects were chosen at random from the waiting room and the same criteria were applied to these subjects as to the patient population. It was explained to the potential subject that the clinic staff periodically made checks on tests utilizing normal subjects. In every case complete cooperation was elicited.

Groups. During the investigation period fifty five patients and twenty four normals were examined. Of this number, fifty two patients and the twenty four normals were found to meet all of the above criteria.[5] These subjects were subdivided into four groups according to anxiety level in the following manner:

1. High anxiety patients (HP):[6] Those patients who were

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[5]One patient was discovered to be under testosterone therapy, one patient was discovered to have central nervous system pathology and one patient was discovered to have cataracts. These three subjects were eliminated from the study.

[6]Hereafter HP will be used to designate the high anxiety patient group.

rated 3.2 or above on A1 and had an anxiety score on A2 of eight or more were designated as high anxiety patients (HP).

2. Low anxiety patients (LP):[7] Those patients who were rated 3.0 or less on A1 and had an anxiety score on A2 of seven or less were designated low anxiety patients (LP).

3. Low anxiety normals (LN):[8] Those controls who were rated 3.0 or less on A1 and had an anxiety score on A2 of seven or less were designated low anxiety normals (LN).

4. High anxiety normals (HN):[9] Those controls who were rated 3.2 or more on A1 and had an anxiety score on A2 of eight or more were designated high anxiety normals (HN).

Those subjects who did not meet the criteria for any group were not included as subjects for this investigation. This eliminated one more patient and one normal subject[10] leaving fifty one patients and twenty three normal subjects.

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[7]Hereafter LP will be used to designate the low anxiety patient group.

[8]Hereafter LN will be used to designate the low anxiety normal group.

[9]Hereafter HN will be used to designate the high anxiety normal group.

[10]One patient was rated high anxiety on A1 and scored low anxiety on A2. One normal was rated high anxiety on A1 and scored low anxiety on A2. Inasmuch as both anxiety measures did <u>not</u> agree, these subjects were eliminated from this investigation.

Table I indicates the number of subjects in each group, the number of males and females in each group, the mean age and age range of each group, and the mean education and education range in number of grades completed for each group. It will be noted that there were thirty three subjects in HP, eighteen subjects in LP, twenty one subjects in LN and two subjects in HN. If one combines all of the high anxiety subjects into one group (H)[11] this group consists of thirty five subjects. If one combines all low anxiety subjects into one group (L)[12] this group consists of thirty nine subjects.

Table I

The Number of Subjects, Mean Age and Age Range, Mean Education and Education Range, and Sex in the Experimental Groups.

	N	Sex		Age		Education	
		Male	Female	Mean	Range	Mean	Range
HP	33	11	22	31.0	17-49	10.2	4-16
LP	18	10	8	28.8	17-47	11.4	5-18
LN	21	12	9	29.1	17-47	10.3	6-14
HN	2	1	1	41.0	40-42	12.0	8-16
H	35	22	17	31.6	17-49	10.3	4-16
L	39	12	23	28.9	17-47	10.8	5-18

[11]Hereafter H will be used to designate the total high anxiety group.

[12]Hereafter L will be used to designate the total low anxiety group.

Appendix F indicates the psychiatric diagnoses of the patients in HP and LP.

4. Order of Test Administration

Each subject first sorted the complaint check list (A2) but this was not scored immediately in order to prevent bias in the interview which followed immediately and supplied the data for filling out the Lorr scales (A1). After these examinations the subject participated in the flicker test.

Chapter IV

RESULTS

The following chapter will describe in detail the results of the analysis of the data on the anxiety measures and flicker fusion measurements obtained in this study.[1]

Anxiety Measures

Reliability of the Lorr ratings (A1): Duplicate ratings of the Lorr scales were obtained; the experimenter rating each of the seventy four subjects and twenty five of them were also rated by a staff psychiatrist.[2] A rank-order correlation of +0.94 with an approximate standard error of 0.025 indicates the high degree of correspondence obtained by the raters.

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[1]Raw data for each subject on the anxiety measures and the flicker test may be found in Appendix G. Special notes on individual subjects may be found in Appendix H.

[2]The assistance of Dr. Jewett Goldsmith, director of the out patient psychiatric clinic and Dr. Tanash Atoynatan, resident in psychiatry, is gratefully acknowledged.

Validity of the anxiety measures: Several attempts were made to ascertain the relationship of the Lorr ratings (A1) and the complaint check list (A2) to the clinical concept of anxiety.

Within the patient population (LP and HP) of fifty one subjects, twenty six, as noted in Appendix F, received a psychiatric diagnosis of anxiety reaction. Of these, twenty three were placed in HP by virtue of their scores on A1 and A2. The remaining three appeared in LP. Of the latter subjects, two were in remission and the third was rated LP on A1 by the examining psychiatrist. Thus, twenty three of the twenty four (96%) patients with a currently active anxiety reaction were placed in HP through the anxiety measures. Only two of the twenty four (8%) nonpatients were evaluated as high anxiety by the Lorr scales and check list. If one considers the diagnosis of anxiety reaction as an adequate criterion against which to evaluate the anxiety measures, one is able to express some confidence in these measures.

Further, A1 and A2 were independently developed as tools to evaluate the same quality, anxiety. If it can be shown that there is a positive relationship between the two techniques for evaluating anxiety level, then one can express increased confidence in A1 and A2 as measures of anxiety. In examining the relationship between A1 and A2, an eta of 0.94 with a standard

error of 0.014 was obtained.[3] Inspection of the scatter diagram indicated that both A1 and A2 separated each subject into the same group (high anxiety or low anxiety)[4] but did not achieve similar ranking of subjects at the extremes of anxiety level. A scarcity of middle range anxiety scores was noted; subjects usually ranking either high or low anxiety on the two measures. This may be due to the method of subject selection since either patients or nonpatients were used.

It would appear appropriate to say that A1 and A2 are probably valid in sorting or classifying subjects into either a low or high anxiety group. It would also appear that the discrimination ability of these two anxiety indices is not as efficient at the extremes of anxiety level, and that we have only limited information about the middle range of anxiety.

Flicker Fusion Measurements

The following data were obtained from the flicker test, and were analyzed for the six groups (HP, LP, HN, LN, H, and L):

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[3]An eta is reported when a chi-square test of linearity indicated a nonlinear relationship. When a linear relationship was suggested by the chi-square test, the product moment correlation is reported.

[4]With the exception of two borderline anxiety level subjects where A1 and A2 were in disagreement. These two subjects were eliminated from the study.

1. Sensitivity to flicker, as measured by the FFT.
2. Precision of judgment, as measured by the slope.
3. Decline in FFT, was defined as the difference between a subject's FFT for the first ten runs (1-10) and his FFT for the last ten runs (21-30). During the course of the experiment, the examiner observed a reduction in sensitivity to flicker in many of the subjects toward the end of the flicker test. A decline in FFT would indicate a decrease in sensitivity to flicker associated with continued exposure to the test.
4. Decline in slope, was defined as the difference between a subject's slope for the first ten runs and his slope for the last ten runs. A decline in slope would indicate more precise judgments associated with continued exposure to the test.

Group data. The following data on flicker fusion measurements for all the groups are summarized in Table II.

High anxiety patients (HP): The mean FFT for this group (N=33) was 31.7 CPS with a sigma of 3.62 CPS and a range of 22.8 to 40.2 CPS. The mean slope was 1.2 CPS with a sigma of 0.39 CPS and a range of 0.6 to 1.9 CPS. The mean decline in FFT was 2.4 CPS with a sigma of 1.33 CPS and a range of -0.3[5] to 5.7 CPS. The mean decline in slope was 0.1 CPS with a sigma of 0.55 CPS and a range of -0.9[5] to 1.5 CPS.

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[5]In the examination of decline in FFT and decline in slope, a negative difference indicates an elevation rather than a decline in the FFT or slope during the last one third of the flicker test as compared with the first one third.

Table II

The Mean and Sigma of FFT, Slope, FFT Decline, Slope Decline in CPS of the 6 Experimental Groups.

GROUPS	N	MEAN FFT	σ FFT	MEAN SLOPE	σ SLOPE	MEAN FFT DECLINE	σ FFT DECLINE	MEAN SLOPE DECLINE	σ SLOPE DECLINE
HP	33	31.7	3.62	1.2	0.39	2.4	1.33	0.1	0.55
LP	18	36.9	1.86	0.8	0.32	0.3	0.78	0.0	0.33
HN*	2	32.0	*	0.8	*	1.6	*	0.4	*
LN	21	37.1	1.55	0.7	0.22	0.2	0.87	0.2	0.41
H	35	31.7	3.17	1.1	0.39	2.3	1.31	0.1	0.50
L	39	37.0	1.68	0.7	0.26	0.3	0.26	0.1	0.37

* No variance calculations made on this group due to the limited N.

Low anxiety patients (LP): The mean FFT for this group (N=18) was 36.9 CPS with a sigma of 1.86 CPS and a range of 34.1 to 40.2 CPS. The mean slope was 0.8 CPS with a sigma of 0.32 CPS and a range of 0.1 to 1.4 CPS. The mean decline in FFT was 0.3 CPS with a sigma of 0.78 CPS and a range of -1.1 to 2.1 CPS. The mean decline in slope was 0.0 CPS with a sigma of 0.33 CPS and a range of -0.5 to 0.7 CPS.

High anxiety normals (HN):[6] The mean FFT for this group (N=2) was 32.0 CPS with a range of 31.4 to 32.5 CPS. The mean slope was 0.8 CPS with a range of 0.6 to 1.0 CPS. The mean decline in FFT was 1.6 CPS with a range of 0.9 to 2.2 CPS. The mean decline in slope was 0.4 CPS with a range of 0.2 to 0.6 CPS.

Low anxiety normals (LN): The mean FFT for this group (N=21) was 37.1 CPS with a sigma of 1.55 CPS and a range of 34.8 to 40.2 CPS. The mean slope was 0.7 CPS with a sigma of 0.22 CPS and a range of 0.3 to 1.1 CPS. The mean decline in FFT was 0.2 CPS with a sigma of 0.87 CPS and a range of -1.8 to 1.2 CPS. The mean decline in slope was 0.2 CPS with a sigma of 0.41 CPS and a range of -0.7 to 0.8 CPS.

Total high anxiety (H): The mean FFT for this group (N=35) was 31.7 CPS with a sigma of 3.17 CPS and a range of 22.8 to 40.2 CPS. The mean slope was 1.1 CPS with a sigma of 0.39 CPS and a range of 0.6 to 1.9 CPS. The mean decline in FFT was

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[6]No variance calculations made on this group due to the limited number of subjects.

2.3 CPS with a sigma of 1.31 CPS and a range of -0.3 to 5.7 CPS. The mean decline in slope was 0.1 CPS with a sigma of 0.50 CPS and a range of -0.9 to 1.5 CPS.

Total low anxiety (L): The mean FFT for this group (N=39) was 37.0 CPS with a sigma of 1.68 CPS and a range of 34.1 to 40.2 CPS. The mean slope was 0.7 CPS with a sigma of 0.26 CPS and a range of 0.1 to 1.4 CPS. The mean decline in FFT was 0.3 CPS with a sigma of 0.26 CPS and a range of -1.8 to 2.1 CPS. The mean decline in slope was 0.1 CPS with a sigma of 0.37 CPS and a range of -0.7 to 0.8 CPS.

Comparison of groups. The differences between groups were tested by the use of Student's t-test. In each case the assumption of homogeneity of variance was tested. Whenever this test resulted in a rejection of the null hypothesis (0.05 level) the modified t-test for the inhomogeneity of variance was used (Dixon and Massey 1951). No significance tests were performed involving HN due to the limited number of subjects (two) in this group. Figure 1 provides the composite graph for each group based on the mean FFT and mean slope for each group. The t-values between all groups on the flicker fusion measurements are summarized in Table III.

FFT: A significant difference was found between HP (31.7 CPS) and LP (36.9 CPS), $P(t=6.78; df=51) < .005$. A significant difference was found between HP (31.7 CPS) and LN (37.1 CPS), $P(t=7.78; df=48) < .005$. No significant difference was found between LP (36.9 CPS) and LN (37.1 CPS), $P(t=0.38; df=37) > .05$. A significant difference was found between H (31.7 CPS) and

Fig. 1.

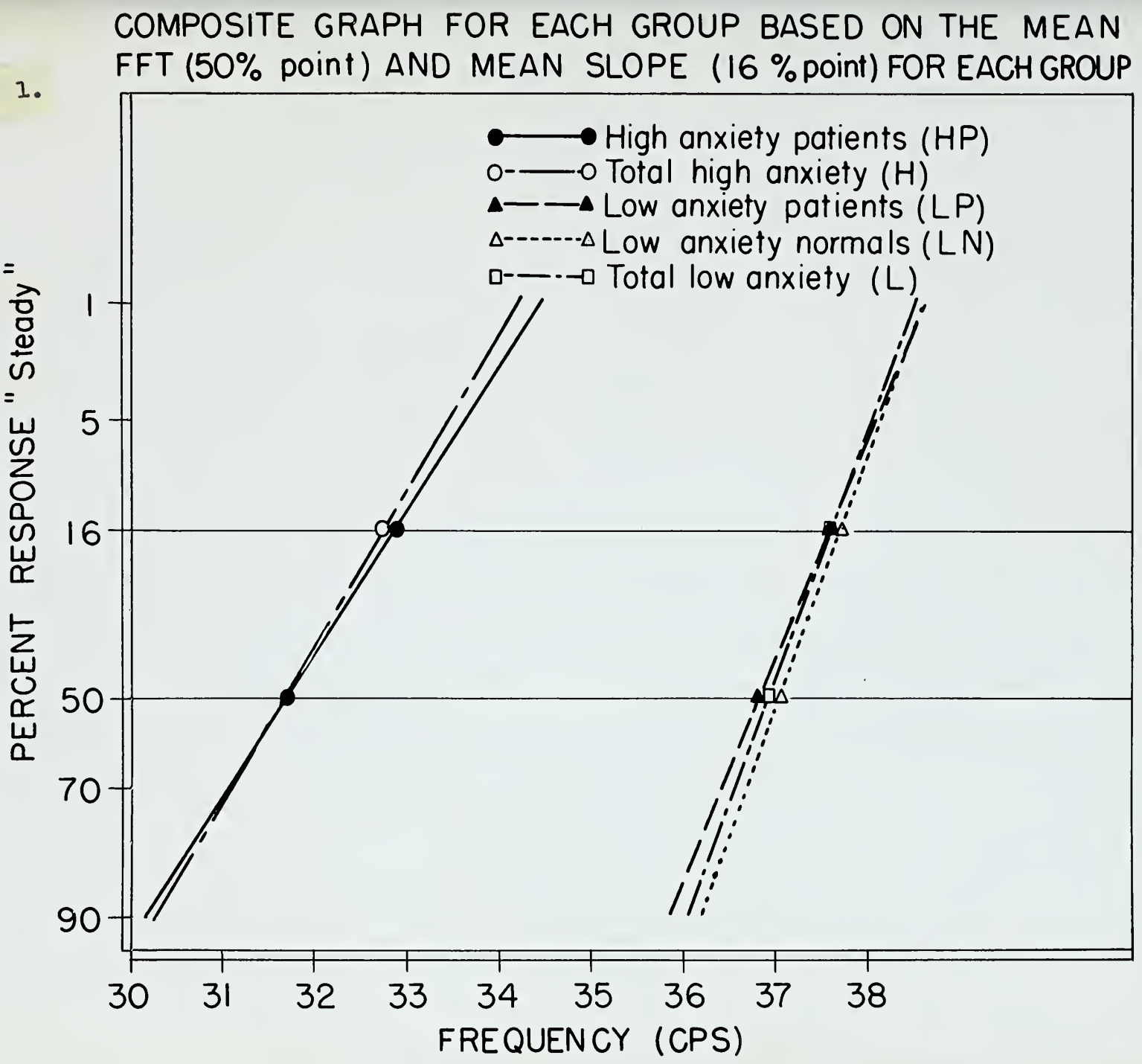

COMPOSITE GRAPH FOR EACH GROUP BASED ON THE MEAN FFT (50% point) AND MEAN SLOPE (16 % point) FOR EACH GROUP
High anxiety patients (HP)
Total high anxiety (H)
Low anxiety patients (LP)
Low anxiety normals (LN)
Total low anxiety (L)
PERCENT RESPONSE "Steady"
1
5
16
50
70
90
30
31
32
33
34
35
36
37
38
FREQUENCY (CPS)

Table III

t-Tests of Reliability of Differences Between the Mean FFT, Slope, FFT Decline and Slope Decline of All Groups.

GROUPS	FFT	SLOPE	FFT DECLINE	SLOPE DECLINE
HP - LP	6.78***	3.91***	7.09***	0.73
HP - LN	7.78***	6.02***	6.72***	0.74
LP - LN	0.38	1.19	0.39	1.74
H - L	8.85***	5.13***	7.75***	0.00

*** t significant at the .005 level of confidence or better.
** t significant at the .01 level of confidence or better.
* t significant at the .05 level of confidence or better.

L (37.0 CPS), P(t=8.85; df=52) < .005.

These results suggest that, in general, subjects designated high anxiety manifest less sensitivity to flicker than do those subjects designated low anxiety.

Slope: A significant difference was found between HP (1.2 CPS) and LP (0.8 CPS), P(t=3.91; df=49) < .005. A significant difference was found between HP (1.2 CPS) and LN (0.7 CPS), P(t=6.02; df=51) < .005. No significant difference was found between LP (0.8 CPS) and LN (0.7 CPS), P(t=1.19; df=37) > .05. A significant difference was found between H (1.1 CPS) and L (0.7 CPS), P(t=5.13; df=60) < .005.

These results suggest that, in general, subjects designated high anxiety manifest greater variability or less precision of judgment than do subjects designated low anxiety.

Decline in FFT: A significant difference was found between HP (2.4 CPS) and LP (0.3 CPS), P(t=7.09; df=49) < .005. A significant difference was found between HP (2.4 CPS) and LN (0.2 CPS), P(t=6.72; df=52) < .005. No significant difference was found between LP (0.3 CPS)and LN (0.2 CPS), P(t=0.39; df=37) > .05. A significant difference was found between H (2.3 CPS) and L (0.3 CPS), P(t=7.75; df= 57) < .005.

These results suggest that generally those subjects designated high anxiety manifest a reduction in sensitivity to flicker concomitant with continued exposure to the flicker test to a greater extent than do those subjects designated low anxiety. For the latter group one may however also note a consistent trend in the direction of decline.

Mean decline in slope: No significant difference was found between HP (0.1 CPS) and LP (0.0 CPS), $P(t=0.73; df=49) > .05$. No significant difference was found between HP (0.1 CPS) and LN (0.2 CPS), $P(t=0.74; df=52) > .05$. No significant difference was found between LP (0.0 CPS) and LN (0.2 CPS), $P(t=1.74; df=37) > .05$. No significant difference was found between H (0.1 CPS) and L (0.1 CPS), $P(t=0.00; df=72) > .05$.

These results indicate that in general there is no significant relationship between anxiety level and the change in variability or precision of judgment from the beginning to the end of the test. All groups except LP manifest a trend in the direction of a decrease in variability. LP showed no change.

Age: From Table I we may note that the mean age of H (31.6 years) is greater than the mean age of L (28.9 years). Age has been reported as relating to FFT; increased age correlating negatively with FFT. It was considered important to evaluate the extent to which the high anxiety subjects differed from the low anxiety subjects with respect to this variable. Analysis of the reliability of the difference in mean age between H and L resulted in a t-value of 1.17 which is significant at less than the .05 level of confidence.

These results suggest that there was not enough of an age difference between the high and low anxiety groups to consider this variable of primary importance in the FFT difference between high and low anxiety groups.

Sex: It can also be seen from Table I that H included more males (22) than females (17), and L included more females (23) than males (12). To what extent is the lower FFT of H

due to the sex differences in both groups? Analysis of the reliability of the difference in mean FFT of males (32.3 CPS) and females (31.5 CPS) in H resulted in a t-value of 2.32 which is significant at the .05 level of confidence. Analysis of the reliability of the difference in mean FFT of males (37.5 CPS) and females (36.3 CPS) in L resulted in a t-value of 9.03 which is significant at the .005 level of confidence. These results suggest a basic difference between males and females in FFT. To what extent does this finding influence the overall results obtained in this study? Analysis of the reliability of the difference in FFT between males in H (32.3 CPS) and males in L (37.5 CPS) resulted in a t-value of 5.30 which is significant at the .005 level of confidence. Analysis of the reliability of the difference in FFT between females in H (31.5 CPS) and L (36.3 CPS) resulted in a t-value of 5.52 which is significant at the .005 level of confidence.

Although it appears that males have a higher FFT than females, these results indicate that reduced sensitivity in the high anxiety groups is independent of sex differences; the FFT in high anxiety males or females being lower than the FFT of the low anxiety subjects of the same sex. A higher FFT in males was also reported by Hartmann (1934) and Miller (1942).

Relationships among flicker fusion measurements and anxiety measures. In order to further elucidate the relationship between the flicker fusion measurements studied (FFT, slope and decline in FFT) and anxiety level (Lorr ratings and complaint

check list) a correlation analysis was performed. Table IV provides a summary of the intercorrelations obtained among the anxiety measures and the flicker fusion data.

Table IV

Intercorrelations between the anxiety measures (Lorr ratings-A1 and complaint check list-A2) and the flicker fusion measurements (FFT, slope, and decline in FFT).

	FFT	Slope	Decline in FFT	A1	A2
FFT					
Slope	-0.50				
Decline in FFT	0.80* (-0.66)	+0.64			
A1	0.85* (-0.69)	+0.54	+0.69		
A2	0.76* (-0.57)	+0.50	+0.62	0.94* (0.87)	

*An eta was used when a chi-square test of linearity indicated a nonlinear relationship. The number in parentheses represents the obtained product moment correlation.

As mentioned earlier the eta of 0.94 obtained between the two anxiety measures suggests that they are both measuring the same quality to a large extent.

Correlations between the anxiety measures (Lorr ratings-A1 and complaint check list-A2) and flicker fusion measurements (FFT, slope and decline in FFT): In examining the relationship between A1 and FFT an eta of 0.85 was obtained. The standard error of the eta was 0.032. In examining the relationship between A1 and slope a product moment correlation of +0.54 was obtained. The standard error of the correlation was 0.083. In examining the relationship between A1 and decline in FFT a product moment correlation of +0.69 was obtained. The standard error of the correlation was 0.061.

In examining the relationship between A2 and FFT an eta of 0.76 was obtained. The standard error of the eta was 0.049. In examining the relationship between A2 and slope a product moment correlation of +0.50 was obtained. The standard error of the correlation was 0.088. In examining the relationship between A2 and decline in FFT a product moment correlation of +0.62 was obtained. The standard error of the correlation was 0.072.

From the above correlations the following is suggested: (1) Further evidence is provided regarding the relationship between sensitivity to flicker, variability of judgment and decline in sensitivity to flicker as a result of continued exposure to the flicker test and anxiety level. The higher the anxiety level the more reduced is the sensitivity to flicker,

the more variable are the judgments and the greater is the reduction in sensitivity as a result of continued exposure to the flicker test. (2) The level of anxiety relates most to the FFT, next to the decline in FFT and least to the slope. (3) The Lorr ratings (A1) as a measure of anxiety level seems to be more closely related to the flicker fusion measurements than is the complaint check list. (4) While a linear relationship seems to exist between anxiety level and slope and decline in FFT, the relationship between anxiety level and FFT provides an S-shaped scatter diagram. The high and low anxiety subjects seem clustered around the low and high FFT values respectively.

Correlations among the flicker fusion measurements (FFT, slope and decline in FFT): In examining the relationship between FFT and slope, a product moment correlation of -0.50 was obtained. The standard error of the correlation was 0.088. In examining the relationship between FFT and decline in FFT an eta of 0.80 was obtained. The standard error of the eta was 0.042. In examining the relationship between slope and decline in FFT a product moment correlation of +0.64 was obtained. The standard error of the correlation was 0.069.

The above correlations suggest that the flicker fusion measurements obtained in this investigation (FFT, slope, and decline in FFT) are related to each other. The high correlation between FFT and decline in FFT suggests that these measures might be evaluating the same quality in the anxious and non-anxious subject.

CHAPTER V

DISCUSSION

From the empirical findings regarding the relationship between anxiety and flicker fusion measurements as reported in the previous chapter, one might make the following statements:

1. The high anxiety groups are less sensitive to a flickering light than are the low anxiety groups. This finding represents a verification of the results of Krugman (1947). Further, the group designated low anxiety patients (LP) demonstrated an FFT not significantly different from the FFT obtained by a low anxiety normal (LN) group, indicating that the lower FFT was not a function of psychiatric illness per se, a possibility left open by the Krugman study.

How reliable is this finding? To what extent may we generalize from it? The magnitude of the difference between the mean FFT's of the high and low anxiety subjects (5.3 CPS) with a resulting t-value of 8.85 indicates a considerable relationship between anxiety level and FFT. This is further demonstrated by the significant correlations between FFT and the anxiety measures; the correlation between the complaint check list (A2) and FFT resulting in an eta of 0.76, and the correlation between the Lorr ratings (A1) and FFT resulting in an eta of 0.85. Further only

three subjects out of thirty five subjects (9%) in the high anxiety group obtained an FFT equal to or greater than the mean of the low anxiety subjects (37.0 CPS); no subject out of the thirty nine subjects (0%) in the low anxiety group obtained an FFT equal to or less than the mean of the high anxiety subjects (31.7 CPS). Thus from the standpoint of the mean FFT, little overlap is noted.

These findings suggest that the FFT is a reliable measure bearing considerable relationship to anxiety level.

2. The high anxiety groups are less precise in their judgments around the threshold than are subjects of the low anxiety groups. It is possible that the increased variability noted in the high anxiety groups is directly related to the function of the visual mechanism. It is also possible that certain factors not directly related to flicker sensitivity are present in the flicker test of the high anxiety subjects. These factors could include the decreased ability to concentrate or attend (Berg 1949) or distractability that is so often observed in anxious persons.

If one assumes that the mean intrasubject variability (slope) value of the low anxiety group (0.7 CPS) represents the average or normal intrasubject variability, then the mean slope value of the high anxiety group (1.1 CPS) suggests the possibility that about 0.4 CPS may be attributed to factors such as described above. Since the magnitude of the difference between mean FFT's of the high and low anxiety groups (5.3 CPS) greatly exceeds the differ-

ence in intrasubject variability (0.4 CPS), we have additional evidence that the reduction in sensitivity to flicker in the high anxiety groups is a reliable finding not primarily dependent upon extraneous factors.

3. Continued exposure to a flickering light decreases the sensitivity to flicker to a greater extent in the high anxiety groups than in the low anxiety groups. Snell (1933) and Kubis and Buckley (1949) reported a decline in FFT in normal subjects as a result of continued exposure to a flickering light. This "fatigue effect" was more pronounced in the high anxiety groups in our investigation. The possible implications of this finding will be discussed shortly.

4. Practice in locating the threshold point results in the same trend toward increased precision of judgment in all groups. If the decline in FFT accompanying exposure to the test described above was a function of increasing boredom, or decreased concentration on the task on the part of the anxious subject, then one might expect the variability of the anxious subjects to increase as the test progressed to a greater extent than in less anxious subjects. Since the opposite was found, it does not seem probable that extraneous factors such as increasing boredom or decreased concentration played a significant role in the decline phenomenon.

The findings of this investigation suggest that the flicker test provides reliable, stable and sensitive measures which relate significantly to anxiety level. Since it appears unlikely that

extraneous factors such as boredom with, or lack of concentration upon the task play a significant role in the flicker test, it would seem that the reduced sensitivity to flicker and the decline in FFT associated with continued exposure to the test represent true psychophysiological phenomena. It would appear that these flicker fusion findings provide other physiological components of the anxiety reaction.

In this light it is interesting to note that blurred vision is commonly recognized as an anxiety symptom (Henderson and Gillespie 1947, May 1953). One wonders if impairment of sensory function is a characteristic of anxiety reaction. It would be of interest to ascertain whether anxiety subjects manifest impairment in other types of visual threshold determinations or in other sense modalities. The findings of this study further indicate the value of a sensory discrimination task in the study of personality variables.

The following discussion will evaluate certain possible hypotheses relevant to the above described findings and suggest possible avenues of future research designed to investigate the hypotheses suggested. In this light it would seem desirable to consider a number of variables which may have influenced these results.

That this reduced acuity to flicker is not just a simple function of the autonomic nervous system reactions usually associated with anxiety may be seen from the following: Sympathetic

stimulants such as adrenalin always raise the FFT in normal subjects. If the usual sympathetic overreaction with resulting adrenergic secretions was a crucial factor for flicker perception in anxious subjects, then one would anticipate an increase in FFT accompanying anxiety. Actually the opposite was found in the present investigation. It is as though the fight-flight function of the autonomic nervous system is immobilized or rendered functionally ineffective as a result of persistent anxiety. This may relate to Selye's (1947) notion of the stage of exhaustion in the general-adaptation-syndrome where: "Apparently under the influence of prolonged adaptive work, the adaptability or 'adaptive energy' of the organism is eventually exhausted." (p. 845) According to this formulation the organism has only a certain amount of adaptability which is used up after prolonged exposure to stress with a resulting adrenal breakdown caused by overwork.

It has repeatedly been reported that mental and physical fatigue reduce acuity to flicker. Henderson and Gillespie (1947) see "general fatiguability" as a common symptom of anxiety. Braceland and Rome (1943) see an interaction of fatigue and anxiety. "...in the frankly psychoneurotic personality...the patient's fatigue is not only proportional to his anxiety but is also induced by it." (p. 827) Is it possible then that anxiety, like circulatory insufficiency, hypoxia, hypothyroidism and vitamin B deficiency is characterized by fatigue reflected in FFT? Is the anxious person in a constant state of fatigue, even while resting?

If this be the case then one might expect the anxious person to be less tolerant of work and thus exhibit signs of fatigue

earlier and to a greater extent than a nonanxious person. As evidence in this direction one might point to the greater decline in FFT from the beginning to the end of the flicker test in high anxiety subjects. Snell (1933) and Kubis and Buckley (1949) reported a decline in FFT in normal subjects as a result of continued exposure to a flickering light. This "fatigue effect" was more pronounced in our high anxiety group. It would therefore seem desirable to further clarify the relationship between fatigue and anxiety suggested by this investigation. This might be accomplished by subjecting high and low anxiety subjects to equal amounts of "work" with a flicker test before and after. A greater decline in FFT after "work" might be anticipated in the high anxiety subjects. For example: One might subject high and low anxiety subjects to equivalent amounts of physical work (e.g., walking a treadmill, etc.) and mental work (e.g., arithmetic calculations, etc.) with a flicker test before and after the tasks. We might anticipate a greater decline in FFT in the high anxiety subjects. Or, one might subject high and low anxiety subjects to a low frequency flickering light for equivalent but relatively long amounts of time. We might anticipate a greater decline in FFT in the high anxiety subjects.

It has been demonstrated that FFT is reduced when oxygen circulation is impaired, whether induced by circulatory insufficiency, anoxia or pharmacologically. Inasmuch as cardiovascular function is thought sometimes to be influenced by anxiety (May 1950, Saul 1944), is it possible that temporary or permanent impairment of the circulatory system occurs with anxiety? May

anxiety be accompanied by a hypertonus of the retinal vessels with a resulting reduction in FFT? It has been shown that hypertonus of the retinal vessels may be reflected in FFT even in preclinical cardiovascular impairment. Although the following is highly speculative, one wonders if persistent anxiety, with its physiological accompaniments sometimes leads to permanent or temporary impairment of cardiovascular function which is reflected in FFT. It may be possible to investigate the influence of oxygen deprivation and the circulatory system upon FFT in anxious subjects through the Krasno-Ivy technique (see Chapter II). If cardiovascular involvement plays a significant role in the reduced sensitivity to flicker then one might expect a higher incidence of "abnormal" nitroglycerine-flicker tests in a high anxiety group than in a low anxiety group. Further, careful study of retinal photographs might provide information concerning possible vasospastic tendencies in anxious subjects. Such research might provide clues for preclinical evaluation of a disposition to hypertensive cardiovascular disease, particularly as it relates to anxious persons.

In studying the decline phenomenon one might consider the possibility that the flicker test itself is anxiety-provoking and thus the decline is in response to threat. This is in line with the notion that increased anxiety results in decreased FFT. If this is the case then the flicker test might provide a sensitive measure of response to danger or stress. It might be anticipated that under stress, a more efficient adrenal system of a low

anxiety subject may result in a raised FFT, while increased strain in the anxious subject might further lower the FFT. According to Selye's (1947) formulations, the countershock phase of the alarm reaction and the stage of resistance would operate in an adaptive fashion for the low anxiety subject. On the other hand, persistent stress in the high anxiety subject brings him to the stage of exhaustion where physiological adaptation is limited and further stress results in further impairment. One might be able to study this notion by introducing a threat or stress in the flicker fusion situation. For example: One might introduce a stress (e.g., shock, gunshot, pursuitmeter, etc.) directly into the flicker test situation after a basal FFT is obtained. It may be anticipated that low anxiety subjects will manifest a rise in FFT while high anxiety subjects will demonstrate a reduction in FFT. Or, one might study the effect of a real-life stress (e.g., important examination, etc.) upon FFT in low and high anxiety subjects. It may be anticipated that low anxiety subjects will manifest a rise in FFT while high anxiety subjects will demonstrate a reduction in FFT.

One of the original purposes of this investigation was to explore the fruitfulness of the flicker technique as an index capable of reflecting change in anxiety level following psychiatric therapy. The possible value of the flicker method in this capacity was suggested by Krugman (1947) after a study indicating a reduced sensitivity to flicker in highly anxious

patients as compared to a normal control group. The flicker test has been demonstrated as a reliable and stable quantitative instrument. Other investigators have demonstrated the sensitivity of FFT to change as a result of treatment or spontaneous improvement where chronic fatigue, hypoxia, and ophthalmologic, central nervous system and cardiovascular pathology were involved.

The comparatively large difference between the mean FFT's of the high and low anxiety groups, in addition to the significant correlations between FFT and the anxiety measures provides evidence that the flicker test might be expected to reflect change in anxiety level as a result of psychiatric therapy. The rise in FFT of 5.1 CPS concomitant with reduced anxiety level in subject No. 8 (see Appendix H) also provides some suggestion concerning the sensitivity of the FFT to changes in anxiety level.

The decline phenomenon, or "fatigue effect" might also provide a measure that might be expected to change concomitant with altered anxiety level. A reduction in anxiety level should decrease the decline in FFT associated with continued exposure to the task.

Although the flicker test shows promise at this stage of its development, considerable caution is suggested in its use in diagnosis. There is considerable individual difference in basal FFT and there are many factors other than anxiety that are known to influence the FFT. Further, much more empirical, normative research is necessary. It is more probable that the flicker test will be found a more fruitful index of change in anxiety level, than in absolute measurement or diagnosis of anxiety level. It

would therefore seem desirable to undertake research designed to investigate the potentiality of the flicker test for evaluating change in anxiety level accompanying a psychiatric therapy. A group of patients might be given the flicker test before and after treatment; anxiety ratings similar to those mentioned earlier being obtained before and after the therapy. One might expect a rise in FFT and a reduction in decline of FFT where anxiety level has diminished; this should not be the case in subjects where the anxiety level remains the same. Conversely, an increase in anxiety level should further lower the FFT and increase the decline in FFT.

Such a research project is now under way at the out-patient psychiatric clinic at Duke Hospital where the differential therapeutic effects of carbon dioxide and nitrous oxide inhalation therapies are being studied. It has been reported (Meduna 1948, 1950, Silver 1951) that carbon dioxide inhalation therapy usually brought relief in cases of anxiety reaction in thirty treatments, or ten weeks of time. Thus one might assemble a large number of treated cases in a relatively short period of time. This will enable us to test the flicker technique in a therapeutic setting in addition to evaluating the therapy itself.

CHAPTER VI

SUMMARY AND CONCLUSIONS

An exploratory study by Krugman (1947) suggested that subjects with an anxiety reaction were less sensitive to a flickering light than were normal subjects. The present study was undertaken to investigate empirically the relationship between flicker fusion measurements and anxiety level, anxiety being defined in terms of those symptoms usually associated with the diagnosis anxiety reaction.

The criteria for anxiety involved two measures, an examiner's rating and a complaint check list on which the subject designated those symptoms applying to him. A cut-off point technique was adopted for each measure which divided the subjects into high and low anxiety groups. When the two measures agreed upon the placement of an individual in either a high or low anxiety group, that subject was included in this study. Two subjects were excluded. The anxiety measures correlated highly with each other (eta 0.94) and correctly designated twenty three of twenty four subjects with a current psychiatric diagnosis of anxiety reaction.

Seventy four subjects meeting specific criteria and selected serially from the patients and relatives in the Duke outpatient

psychiatric clinic were separated into four groups; 33 high anxiety patients, 18 low anxiety patients, 2 high anxiety normals and 21 low anxiety normals. Further, all high anxiety subjects were designated as one group (35 subjects) and all low anxiety subjects were designated as another (39 subjects).

A stable, noiseless electronic apparatus provided a low intensity flickering light with a frequency range of from 18-60 cycles-per-second. All subjects received fifteen ascending and fifteen descending method of limits runs alternately with a thirty second rest after each ten runs. A flicker fusion threshold was obtained from the last twenty runs by determining graphically on normal probability paper that frequency which the subject might report as flicker fifty percent of the time. A measure of intra-subject variability was also obtained. In addition a comparison was made of the flicker fusion threshold and variability of the first ten trials ~~as compared~~ with the last ten trials of the flicker test.

It was found that the group designated high anxiety (mean FFT of 31.7 CPS) was less sensitive to a flickering light than was the low anxiety group (mean FFT of 37.0 CPS), $P(t = 8.85; df = 52) < .005$. A similar relationship was found between high anxiety patients and low anxiety patients and normals. There was no significant difference in sensitivity to flicker between the low anxiety patient and low anxiety normal groups. The high anxiety group (mean slope of 1.1 CPS) showed a greater variability in judgment on the flicker test than did the low anxiety group (mean

slope of 0.7 CPS), $P(t = 5.13; df = 60) < .005$. A similar relationship was found between high anxiety patients and low anxiety patients and normals. It was also observed that continued exposure to the flicker test decreased the sensitivity to flicker to a greater extent in the high anxiety group (mean decline in FFT of 2.3 CPS) than in the low anxiety groups (mean decline in FFT of 0.3 CPS), $P(t = 7.75; df = 57) < .005$. A similar relationship was found between high anxiety patients and low anxiety patients and normals. Further, practice in locating the threshold point resulted in the same slight trend toward increased precision of judgment in all groups.

On the basis of data obtained in this study, age and sex, and it was suggested that boredom, distractability or lack of attention as well, did not seem to be the crucial determinants of this impaired ability to perceive flicker. It is concluded that this reduced sensitivity to flicker in anxious subjects is another psychophysiological concomitant of <u>anxiety reaction</u>.

The possible relationship of the autonomic nervous system, the circulatory system, fatigue and stress with respect to the reported flicker fusion phenomena were discussed. Possible future research approaches were proposed.

The findings of this investigation suggest that the flicker test provides quantitative, reliable, stable and sensitive measures which relate significantly to anxiety level. The comparatively large difference between the mean flicker fusion thresholds and decline in threshold with continued exposure to the test,

of the high and low anxiety groups, in addition to the significant correlations between the flicker fusion measures and anxiety level provides encouraging evidence that the test might be expected to reflect change in anxiety level as a result of psychiatric therapy. Research to evaluate the potential of the flicker test in this capacity is now under way at Duke Hospital.

APPENDICES

Appendix A

THE FLICKER FUSION METHOD: EXPERIMENTAL VARIABLES

The FFT is affected by several experimental variables which have been studied rather extensively in the past. Much of this work has been summarized by Bartley (1941) and Granit (1936) whose writings have been referred to as sources by many investigators. The following is a discussion of some of the more important experimental variables and their relevance to the present experiment.

Intensity of light. The relation between FFT and log intensity of illumination is approximately linear. This relationship, known as the Ferry-Porter law is valid for a limited central region of intensity. At low and high intensities the curve tends to become horizontal, and at very high intensities it even descends somewhat (Granit and Harper 1930, Hylkema 1942). Werner and Thuma (1940) in their study of the comparative FFT's of feebleminded children with birth injuries of the brain and those with no history of injury, noted that the difference in FFT was most marked at low intensity of illumination. Halstead (1943, 1947a) also observed a greater differentiation of groups by utilizing a

light source of low intensity. In accordance with these observations, a target patch of low intensity was provided in this investigation.

Light:Dark ratio. The influence of the light:dark ratio on FFT at various intensity levels was described by Bartley (1941). He observed that a light:dark ratio of near 1:0 is the condition for maximum FFT in the low intensity area, whereas at high intensities a low light:dark ratio gave a maximum FFT. More recently Winchell and Simonson (1951) further clarified the relationship between light:dark ratio and FFT. They kept the illumination constant at all points in their experiment and demonstrated a continuous decrease in FFT from low to high light:dark ratio. A light:dark ratio of about 50:50 was most frequently used in the studies described in Chapter II. Enzer, et al. (1944) found the FFT a more sensitive index of brain damage at fifty percent light than at seventeen and one half percent light. The 60:40 light:dark ratio suggested by Simonson and Enzer (1941) and Misiak (1947, 1948) was adopted for this study.

Area of test patch. In general, if the flickering area is increased the FFT rises in the same manner as with increased intensity (FFT is proportional to log area). Small areas give a lower fusion frequency in the periphery than in the center of the retina, while larger targets give a lower value in the center than in the periphery (Granit and Harper 1930). A test patch circular in shape and 5-mm in diameter (Misiak 1947, 1948, Riccuiti 1949) was adopted for this study. This size permitted

foveal fixation at a convenient distance from the target.

Adaptation. Lythgoe and Tansley (1929) demonstrated that the central FFT falls during dark adaptation and with decreasing levels of light adaptation, and is highest when the brightness of the test patch and the surrounding area are equal. The peripheral FFT rises during dark adaptation and decreasing levels of light adaptation and is highest in completely dark surroundings. Granit (1936) stated that a pure "cone-eye" such as the human fovea changes its FFT only slightly or not at all with the state of adaptation. Apparently the periphery is more affected by the process of adaptation than the center. Since foveal adaptation does not appreciably affect FFT, only three minutes of adaptation to the dim background illumination was provided in this study.

Duration of stimulus exposure. The FFT reaches its maximum during the first second of exposure. In foveal fixation FFT remains the same for ten seconds and falls somewhat thereafter. In peripheral fixation FFT decreases rapidly after the first second (Granit and Ammon 1930). Riddell (1936) suggests one to one and one half seconds as the optimal exposure time and this suggestion was adopted for the present investigation.

Foveal vs. peripheral stimulation. From Creed and Ruch (1930), Granit and Harper (1930), Hecht and Verrijp (1933) and Lloyd (1952) one may conclude that flicker is more marked in the periphery than in the center of the field of vision under conditions of moderate intensity of illumination and a target of moderate size,

but that the contrary is true with intense stimuli and small objects. Since foveal measurements are simpler to obtain and are more stable and less variable than peripheral measurements; and since they have been employed almost exclusively in the clinical research described in Chapter II, central determinations were used for this experiment.

Monocular vs. binocular fixation. Berg (1949) states: "Binocular and monocular central fixation give the same fusion number, but there is greater dispersion among the values for monocular fixation." Sherrington (1904) reported only minor differences between the two methods of fixation. However a repetition of the Sherrington study (Ireland 1950a) demonstrated a higher FFT for binocular in-phase stimulation than monocular fixation. McNemar (1951) found that both methods ordered subjects in the same manner. Since binocular and monocular fixation apparently order subjects in the same fashion, and there is apparently less variability in binocular fixation, and binocular fixation is a simpler procedure and the usual one in clinical research, we used the binocular approach.

Acuity. Several writers (Hylkema 1943, Lebensohn 1950, Miles 1950b) observed that ordinary problems of acuity do not influence FFT measurements. On the basis of these observations, ordinary acuity problems were not eliminated as subjects. The use of eyeglasses was permitted during the flicker test.

Stability of the FFT. Misiak (1948a) examined repeated FFT measurements taken over a long period of time. He concluded: "An

evaluation of the data obtained in this research warrants the conclusion that CFF does not change significantly from day to day." (p. 225) Other workers have also demonstrated the reliability of this method (Berg 1949, Brozek and Keys 1944a and b, Enzer et al. 1941, Lilienthal and Fugitt 1945, Miles 1951, Simonson and Winchell 1951).

As a final point in this discussion of the experimental variables in an FFT determination, one might make mention of a warning referred to by several writers (Lythgoe and Tansley 1929, Landis 1951, McNemar 1951, Riccuiti 1949, Winchell and Simonson 1951). Unless the experimental variables are carefully controlled, equated and specified one cannot compare the absolute values of FFT in two or more experiments. This may account for some of the apparent contradictions where one study reports differences between two groups under a given condition and another doesn't. Perhaps it would be best if all reported FFT's were qualified by the experimental conditions.

Appendix B

THE FLICKER FUSION METER

The light source in this flicker fusion meter was a Sylvania R1131A. Controls were provided to regulate frequency, light:dark ratio, intensity of illumination, and duration of presentation of the stimulus. A calibration or zero set was also provided.

Frequency monitoring was accomplished by means of an NE 51 coupled across the saw-tooth oscillator and a 60-cycle voltage from the power transformer. Sixty, thirty and twenty CPS were indicated by an unmodulated pilot light. A "zero set" for the oscillator was used to compensate for any drift that might have occurred.

The saw-tooth oscillator indicated in the block diagram (see fig. 2) is a conventional thyratron sweep circuit without special linearization. The oscillator has a gross range of approximately 18-65 CPS.

The proportional clipper determined the light:dark ratio and consisted of an NE 51 lamp on the cathode follower output of the oscillator. This light came on at a voltage determined by the light:dark ratio adjusting control and remained on to the end of that cycle.

The output of the clipper was squared by saturating half of a 6 SN 7 which was coupled to the power amplifier tube.

An automatic stimulation period was provided by a duration gate consisting of an OA 4 G which discharged through the cathode of the power tube and so cut it off.

The frequency dial was calibrated with a cathode ray oscilloscope by having the 60 point on the dial set at exactly 60 CPS and then finding the dial settings for the following frequencies: 18, 20, 24, 25, 30, 35, 36, 40, 42, 45, 48, 50, 54, and 55. A graph was then drawn to establish the dial setting for any frequency and vice versa. The instrument's calibration was constantly checked by the 60-cycle neon zero set.

The block and circuit diagrams for the flicker fusion meter may be found in figure 2.

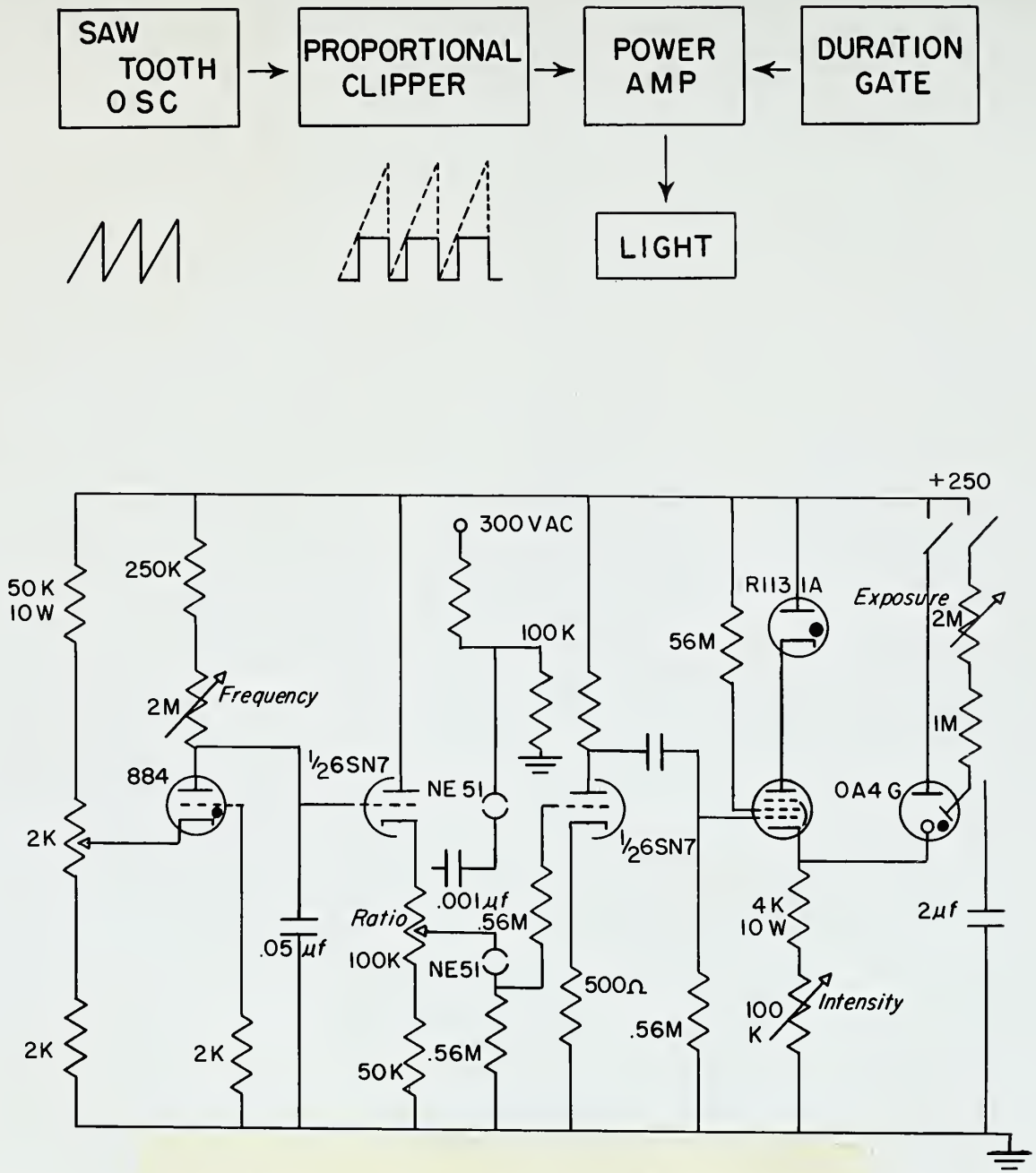


Fig. 2. Circuit and block diagrams for the flicker fusion electronic unit.

Appendix C

FLICKER FUSION MEASUREMENTS: SAMPLE DATA SHEET AND NORMAL PROBABILITY GRAPH

The following pages contain a sample data sheet and normal probability graph obtained from the flicker test of subject No. 26.

Each number (6-47) on the first row of the data sheet represents a single frequency. The first number (6) represents a frequency of 24.5 CPS and the last number (47) represents a frequency of 45.0 CPS. The step interval (e.g., 6 to 7, 7 to 8, 8 to 9, etc.) is 0.5 CPS.

Each of the following thirty rows on the data sheet represents a method of limits run; the odd numbered rows corresponding to the ascending runs and the even numbered rows corresponding to the descending runs. A <u>check</u> (✓) indicates a report of <u>flicker</u> and a <u>cross</u> (X) indicates a report of <u>steady</u> for a given frequency. It will be noted that each ascending run was terminated when the subject gave three consecutive reports of steady and each descending run was terminated when the subject gave three consecutive reports of flicker. Each run was initiated two step intervals (1.0 CPS) above or below the frequency terminating the preceding run.

The percentage of reports "flicker" on the last twenty runs (next to the last row on the data sheet) was determined for each frequency (last row on the data sheet). A similar computation was accomplished for the first ten runs and the last ten runs separately. These percentages do not appear on the sample data sheet.

The obtained percentages were then plotted on normal probability paper (see the sample) on the assumption that these values were normally distributed. Two derived measures were obtained from these plots. The first was the FFT which was defined as the frequency at which the subject reported flicker fifty percent of the time. The second was a measure of the slope of the curve defined as the difference between the frequency producing fifty percent reports of flicker and the frequency producing sixteen percent reports of flicker. This value is the standard deviation of the distribution.

For the demonstration subject (No. 26) the following values were obtained from the normal probability graph:

	FFT (CPS)	Slope (CPS)
Last twenty runs (11-30)	31.6	1.3
First ten runs (1-10)	34.6	0.7
Last ten runs (21-30)	30.7	0.9

Sample Flicker Fusion Data Sheet

SUBJECT #26

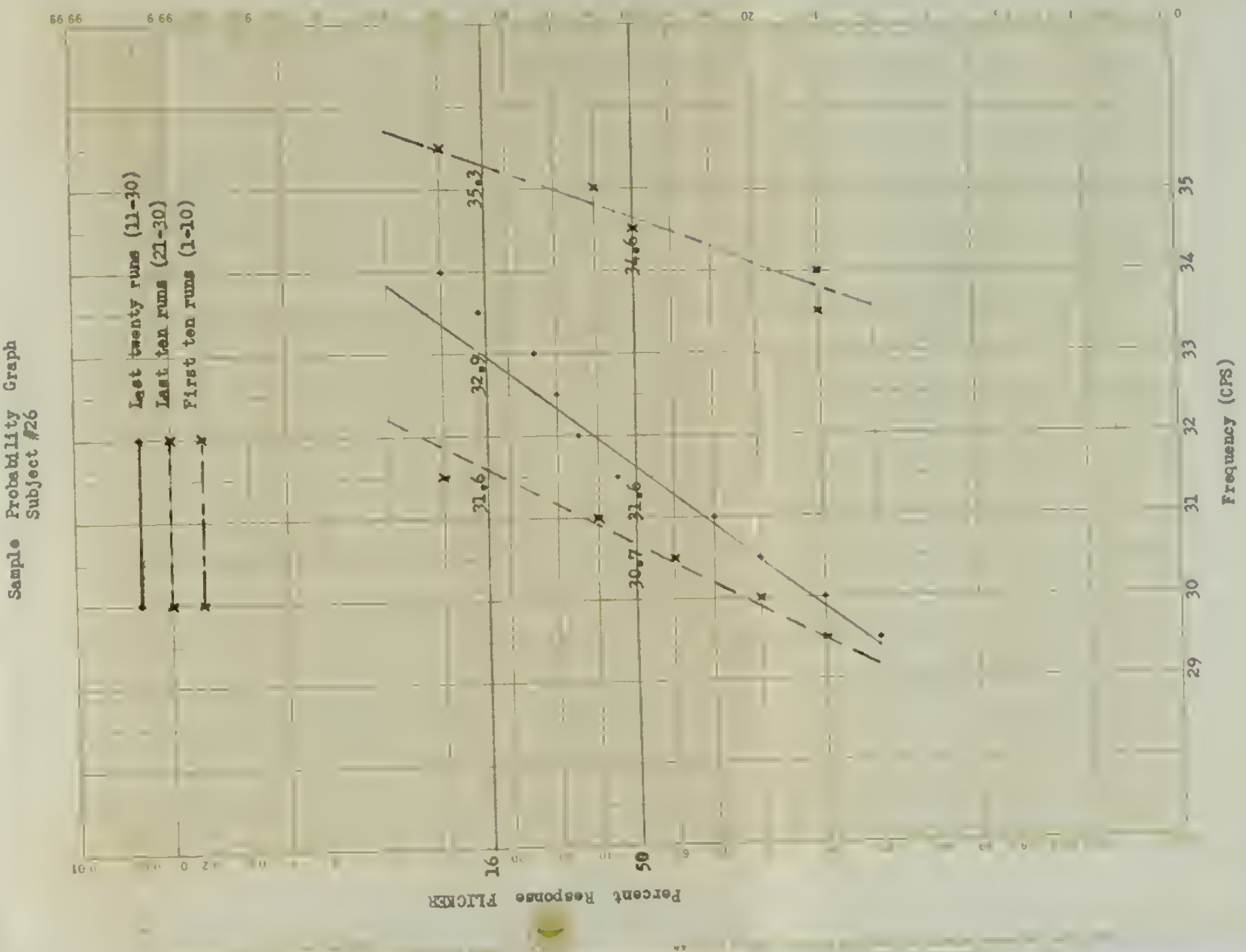
✓ Flicker

X Steady

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
1																✓	✓	✓	✓	✓	✓	✓	X	X	X																	
2																				✓	✓	✓	X	X	X	X	X																
3				✓		Flicker												✓	✓	✓	✓	✓	X	X	X																		
4																			✓	✓	✓	X	X	X	X	X	X															
5				X		Steady											✓	✓	✓	✓	✓	✓	✓	X	X	X																	
6																		✓	✓	✓	X	X	X	X	X	X	X	X														
7																✓	✓	✓	✓	✓	X	X	X																		
8																		✓	✓	✓	X	X	X	X	X																
9																✓	✓	✓	✓	✓	X	X	X																		
10						(30 second rest)										✓	✓	✓	X	X	X	X	X	X	X																	
1														✓	✓	✓	✓	✓	✓	✓	X	X	X																		
2																		✓	✓	✓	X	X	X	X	X																
3																✓	✓	✓	✓	✓	X	X	X																		
4														✓	✓	✓	X	X	X	X	X	X	X	X	X																
5												✓	✓	✓	✓	✓	✓	✓	X	X	X																		
6															✓	✓	✓	X	X	X	X	X	X																		
7													✓	✓	✓	✓	✓	✓	X	X	X																		
8												✓	✓	✓	X	X	X	X	X	X	X	X	X	X																
9										✓	✓	✓	✓	✓	✓	X	X	X																					
10						(30 second rest)						✓	✓	✓	X	X	X	X	X	X																				
1										✓	✓	✓	✓	✓	✓	X	X	X																					
2										✓	✓	✓	X	X	X	X	X	X	X	X	X																		
3									✓	✓	✓	✓	✓	✓	✓	X	X	X																					
4											✓	✓	✓	X	X	X	X	X	X	X																			
5										✓	✓	✓	✓	✓	✓	X	X	X																					
6										✓	✓	✓	X	X	✓	X	X	X	X	X																			
7								✓	✓	✓	✓	✓	✓	✓	X	X	X																					
8										✓	✓	✓	X	X	X	X	X	X	X																			
9									✓	✓	✓	✓	✓	✓	X	X	X																					
10									✓	✓	✓	X	X	X	X	X	X	X	X																			
											19	18	16	14	9	7	6	5	3	2																			
											95	90	80	70	45	35	30	25	15	10																			
												30		31		32		33		34																			

Number reported "flicker" for the last twenty runs.
Percent response "flicker" from e base twenty.
Frequency (CPS) for each column.

Sample Probability Graph



Appendix D

THE LORR ANXIETY-TENSION RATING SCALES (A1)

The following page contains a sample copy of the Lorr anxiety-tension rating scales. Tension, irritability, anxiety and frustration tolerance are rated on six point scales, while sleep complaints are rated on a four point scale.

To demonstrate the scoring procedure the sample copy of A1 has been rated for a hypothetical subject. The following ratings are provided:[1]

Sleep Complaints	3
Tension	5
Irritability	4
Anxiety	5
Frustration Tolerance	5
Total	22

The above total (22) divided by the number of scales (5) provides the index of anxiety, in this case 4.4. Since the obtained index is more than 3.2, this subject would be assigned to a high anxiety group.

---

[1] The numbers on the tension and frustration tolerance scales were reversed. The correct numbers have been typed in to avoid confusion.

Sample Copy of Lorr Scales (A1)

NAME:

DATE:

SLEEP COMPLAINTS

1. Sleep is rarely difficult to begin, restless or interrupted
2. Sleep is sometimes begun with difficulty, restless or interrupted.
X 3. Sleep is often begun with difficulty, restless, or interrupted.
4. Sleep is very frequently begun with difficulty, restless or interrupted.

TENSION:

X.6. Consistently tense, "nervous", and excitable. Unable to relax.
X X.5. Usually tense, "nervous", and excitable. Seldom relaxes.
X.4. A little tense and "nervous". Slow to relax.
X.3. More inclined to be relaxed than tense and excitable.
X.2. Usually relaxed and calm. Seldom tense or "nervous".
X.1. Consistently relaxed. Rarely disturbed.

IRRITABILITY

1. Rarely irritable or grouchy.
2. Only occasionally irritable or grouchy.
3. Irritable or grouchy somewhat less than average.
X 4. Irritable or grouchy somewhat more than average.
5. Irritable and grouchy fairly often.
6. Consistently irritable. Has temper tantrums or rage reactions when provoked.

ANXIETY

1. Completely untroubled and unworried.
2. Generally placid. Rarely shows concern or uneasiness even when it would appear appropriate.
3. Shows a little less concern than called for by circumstances
4. A little over-anxious or over-concerned. Shows marked signs of tension.
X 5. Reports strong feelings of impending misfortune. Shows marked signs of tension.
6. Agitated or panicky with anxiety. May anticipate tragic and inescapable misfortunes or disasters.

FRUSTRATION TOLERANCE

X.6. Rarely able to maintain emotional control under stress or frustration.
X X.5. Usually loses emotional control under stress or frustration
X.4. Somewhat less able than average to maintain emotional control under stress or frustration
X.3. Somewhat better able than average to maintain emotional control under stress or frustration.
X.2. Seldom shows loss of emotional control under stress or frustration.
X.1. Very rarely shows loss of emotional control under stress or frustration.

Appendix E

THE COMPLAINT CHECK LIST (A2)

A psychiatric complaint check list which contains many of the usual psychiatric complaints, in the process of development at Duke Hospital for the purpose of evaluating symptomatic change as a result of psychiatric therapy, was utilized as a second criterion of anxiety level.

A survey of the literature on anxiety reaction and the many relevant inventory-type tests brought to light many of the complaints usually related to anxiety reaction as defined in the recent American Psychiatric Association Manual (1952). These complaints were included in the above-mentioned check list and the entire list was presented to the staff of the Department of Psychiatry[1] with the following instructions:

We are developing procedures to be used in the evaluation of therapy, and among these procedures is one in which the patient will select his complaints from among a group of cards on which most of the usual psychiatric complaints are included.

---

[1] The following staff members of the Department of Psychiatry, Duke Hospital, participated in the judging of the complaint check list items with regard to their relevance to anxiety reaction: Dr. Louis D. Cohen, Assistant Professor, Clinical Psychology; Dr. Bingham Dai, Professor of Mental Hygiene and Psychotherapy; Dr. Jewett Goldsmith, Associate in Psychiatry; Dr. Leslie B. Hohman, Professor of Psychiatry; Dr. Vernon Kinross-Wright, Associate in Psychiatry; Dr. Hans Lowenbach, Associate Professor of Psychiatry; Dr. Leonard J. Ravitz, Instructor in Psychiatry; Dr. George A. Silver, Assistant Professor of Psychiatry; Dr. R. Burke Suitt, Assistant Professor of Psychiatry. Their willing assistance is gratefully acknowledged.

One procedure that can be followed in selecting those complaints that are common for a specific disease is to have a number of psychiatrists check through these cards and select those complaints that are common for that disease. The disease we are interested in is that condition known as anxiety reaction which is described in the new APA "Diagnostic and Statistical Manual: Mental Disorders" as follows:

> In this kind of reaction the anxiety is diffuse and not restricted to definite situations or objects, as in the case of phobic reactions. It is not controlled by any specific psychological defense mechanism as in other psychoneurotic reactions. This reaction is characterized by anxious expectation and frequently associated with somatic symptomatology. The condition is to be differentiated from normal apprehensiveness or fear. The term is synonymous with the former term "anxiety state".

In helping us establish this scale we would like you to look through these cards selecting those that in your experience are common to anxiety reactions and separating them from the rest of the cards.

With the help of a number of expert judges, we hope to establish a basic scale that could be used to chart the significant changes in complaints which follow treatment.

Those complaints in the entire check list agreed upon by six out of the nine judges as anxiety-related were selected as the anxiety complaints. Using this procedure, twenty three separate items were isolated and designated as anxiety complaints.

The check list consists of the following one hundred and eleven statements of which the twenty three underlined items constitute those anxiety complaints selected by the staff at Duke Hospital. The number in parenthesis following each complaint indicates the number of judges who considered that item to be relevant to anxiety reaction.

COMPLAINT CHECK LIST

1. I find it hard to catch my breath. (7)
2. I feel as if I am choking. (7)
3. My doctor tells me I have hayfever. (0)
4. My doctor tells me I have asthma. (0)
5. I blush easily. (1)
6. I notice a swelling of my ankles or fingers. (1)
7. I have pains in my chest. (6)
8. My doctor tells me I have high blood pressure. (3)
9. My heart pounds so hard and fast that I can feel it. (7)
10. I notice a burning feeling when I urinate. (2)
11. I wet in bed. (0)
12. Sexual intercourse is painful for me. (1)
13. My monthly periods are painful. (2)
14. My monthly periods are not regular. (1)
15. My attempts at sexual intercourse are unsuccessful. (3)
16. I notice that I have to urinate frequently. (4)
17. I am troubled with gas on my stomach. (5)
18. I eat little. (2)
19. I have little appetite. (3)
20. I am often sick to my stomach. (5)
21. I have loose bowel movements. (6)
22. Doctors tell me I have an ulcer. (0)
23. I have pains from around my stomach. (5)
24. I have an enormous appetite. (1)
25. I overeat. (1)
26. I am troubled by attacks of nausea and vomiting. (5)
27. I am constipated. (1)
28. I sweat very easily, even on cool days. (7)
29. I break out with a rash on my skin. (3)
30. My doctor tells me I have diabetes. (0)
31. I notice my hand shakes when I try to do something. (6)
32. I have back pains. (3)
33. My doctor tells me I have arthritis. (0)
34. I have trouble with my muscles twitching or jumping. (5)
35. I hurt in my arm or leg muscles. (3)
36. I find it difficult to talk because of stuttering. (1)
37. I find it difficult to talk because of stammering. (1)
38. I find it hard to fall asleep at night. (7)
39. My sleep is disturbed and fitful. (5)
40. I am awakened by noise. (2)
41. I wake up early in the morning and find myself unable to go back to sleep. (1)
42. I have dizzy spells. (6)
43. I notice that my mouth is dry. (7)
44. I faint. (3)
45. My doctor tells me I have epilepsy. (0)
46. My vision is blurred. (6)
47. I notice my ears ringing and buzzing. (4)
48. I have headaches. (4)
49. There seems to be a lump in my throat. (4)
50. I have trouble swallowing. (6)

51. I tire quickly and everything I do is a strain for me. (2)
52. My legs become tired and weak very quickly. (4)
53. My arms become tired and weak very quickly. (4)
54. I feel weak all over. (6)
55. I wake up tired and weak in the mornings. (3)
56. I smoke too much. (6)
57. Nothing satisfies me. (2)
58. I get excited easily. (7)
59. I worry about my health. (3)
60. I feel that I am about to go to pieces. (9)
61. I am a nervous person. (8)
62. I have no self-confidence. (3)
63. I shrink from facing a crisis or difficulty and feel that difficulties are piling up so high that I cannot overcome them. (3)
64. I am afraid of things or people I know cannot hurt me. (3)
65. I feel fear about something or someone. (6)
66. I have nightmares. (4)
67. I feel as if something dreadful is about to happen. (9)
68. I am self-conscious. (3)
69. I have periods of restlessness and I cannot sit long in a chair. (4)
70. I am afraid of hurting other people's feelings. (2)
71. My feelings get hurt. (0)
72. I expect to fail in things I do. (1)
73. I become upset. (5)
74. I find myself worrying over something that really isn't important. (4)
75. I worry about myself. (7)
76. Some unimportant thought runs through my mind and bothers me for days. (0)
77. I cannot forget the mistakes I have made. (0)
78. I give up quickly when things go wrong. (0)
79. I have trouble keeping my mind on one thing, or concentrating on what I am doing. (4)
80. I find myself forgetting things. (3)
81. I have strange and peculiar thoughts. (0)
82. I feel that life isn't worth living. (0)
83. I have fits of crying that I cannot control. (1)
84. I am not living the right kind of life. (0)
85. I feel blue, downhearted or depressed. (1)
86. I have fits of laughing that I cannot control. (0)
87. I am afraid I am losing my mind. (6)
88. I feel like doing something rash or harmful. (1)
89. I find it hard to control my sex urges. (0)
90. I am attracted to members of my own sex. (0)
91. I have no sexual desires. (0)
92. I flare up if things do not go my way. (2)
93. I find myself cross and grouchy. (1)
94. I am scared to be alone. (6)
95. I worry over possible troubles. (8)
96. I take things hard. (0)
97. People pick on me. (0)

98. I am shy and sensitive. (1)
99. Nobody understands me. (0)
100. I am not treated fairly. (0)
101. I am easily embarrassed. (1)
102. I cannot do well when people are watching me. (2)
103. I feel inferior. (1)
104. I cannot do anything well. (0)
105. I think I am useless and good for nothing. (0)
106. I expect so little of myself that I do not accomplish much. (0)
107. I expect so much of myself that I never reach my goals. (0)
108. I have trouble making up my mind and coming to decisions.(4)
109. Taking drugs is a problem for me. (0)
110. Drinking is a problem for me. (0)
111. There is nothing in my daily life that keeps me interested. (1)

Administration of A2. In accordance with the technique devised for utilizing A2 in research evaluating symptomatic change as a result of therapy, the following administration procedure was applied: First, the subject was instructed as follows: "Read each card carefully and decide whether the statement on it applies to you or not. Do this with all the cards in front of you until they have been separated into two piles, those that apply to you and those that do not."

When this was completed, the patient was instructed as follows: "Now look through the cards that apply to you and pick out the one that is most important to you." This is done until all of the complaints are ranked in order of importance. When the number of complaints selected was large, the patient was asked first to select the ten most important, which were then ranked; then the next ten most important, etc. In many cases, limited time prevented a ranking of all complaints and in these instances the thirty most important complaints were ranked.

Scoring: Two scoring systems were applied at first:

(1) Weighted Anxiety Complaints: Each anxiety item found within the first five complaints (1-5) was given a score of 5; each anxiety item found within the second five complaints (6-10) was given a score of 4; each anxiety item found within the third five complaints (11-15) was given a score of 3; each anxiety item found within the fourth five complaints (16-20) was given a score of 2 and the remaining anxiety items were assigned a score of 1.

The anxiety score was the sum of all the weighted scores.

(2) Unweighted Anxiety Complaints: The anxiety score was the sum total of anxiety items.

Inasmuch as the two techniques seemed, in preliminary observation on twenty subjects, to separate subjects in approximately the same rank order (rho = 0.85) the second and simpler scoring procedure was adopted for this study. It was decided on the basis of preliminary observations (on twenty subjects) to assign all subjects with 7 anxiety complaints or less to the low anxiety group and those with eight or more to the high anxiety group. Further research with the check list is planned in order to further evaluate its value as an index of anxiety level and its potential for indicating symptomatic change as a consequence of therapy.

Appendix F

DIAGNOSES OF PATIENTS IN HP AND LP

Diagnosis	HP	LP	Total
I. PSYCHOTIC DISORDERS			
Schizophrenic Reaction Hebephrenic Type		1	1
Schizophrenic Reaction Residual Type		1	1
			2
II. PSYCHONEUROTIC DISORDERS			
Anxiety Reaction	23	3 (2*)	26
Conversion Reaction		1	1
Obsessive-Compulsive Reaction	1	1	2
Depressive Reaction	3	3	6
			35
III. PSYCHOPHYSIOLOGICAL DISORDERS			
Psychophysiological Respiratory Reaction		1	1
Psychophysiological Nervous System Reaction		2	2

Diagnosis	HP	LP	Total
Psychophysiological Musculo-Skeletal Reaction		1	1
Psychophysiological Genito-Urinary Reaction		1	1/5
IV. PERSONALITY DISORDERS			
Passive-Aggressive Personality	2		2
Emotionally Unstable Personality	1		1
Schizoid Personality		1	1
Dyssocial Reaction		1	1/5
V. TRANSIENT SITUATIONAL PERSONALITY DISORDERS			
Adult Situational Reaction	1	1	2/2
VI. UNDIAGNOSED	2		2
Total	33	18	51

*In Remission

Appendix G

INDIVIDUAL SUBJECT FLICKER FUSION AND ANXIETY LEVEL DATA

The following represents a tabulation of the flicker fusion and anxiety level data gathered for each subject in this investigation. The table includes:

Column 1	The number assigned to each subject. A number followed by a c (e.g., 2c, etc.) indicates the subject to have been a control. The others were patients.
Column 2	The total FFT obtained by each subject.
Column 3	The total slope value obtained by each subject.
Column 4	The FFT obtained by each subject for the first one third of the flicker test (trials 1-10).
Column 5	The FFT obtained by each subject for the last one third of the flicker test (trials 21-30).
Column 6	The slope value obtained by each subject for the first one third of the flicker test (trials 1-10).
Column 7	The slope value obtained by each subject for the last one third of the flicker test (trials 21-30).
Column 8	The number of anxiety items (out of a possible twenty three) chosen from the complaint check list (A2).
Column 9	The anxiety level index obtained from the Lorr scales (A1) by the experimenter.
Column 10	The anxiety level index obtained from the Lorr scales (A1) by a staff psychiatrist.

1	2	3	4	5	6	7	8	9	10
1	30.1	0.8	30.9	29.7	1.6	0.8	10	4.8	
2	40.2	0.8	40.4	39.9	0.4	0.4	9	3.8	
3	35.9	0.1	35.8	35.8	0.0	0.0	3	2.4	1.8
4	32.1	1.6	33.7	31.9	1.4	1.0	11	4.4	4.0
5	32.9	1.7	35.6	32.4	1.9	1.5	10	4.8	
6	34.1	0.8	36.0	33.9	1.1	0.8	5	2.6	
7	36.0	1.0	36.3	36.0	1.1	1.1	2	2.8	
8	27.5	1.8	31.6	27.0	1.7	1.4	8	4.4	
9	34.7	1.3	35.9	34.3	1.4	1.0	5	2.8	
10	38.3	0.6	38.6	38.0	0.7	0.8	3	2.8	
11	28.5	0.7	28.1	28.4	1.3	0.8	13	4.8	4.8
12	28.5	1.2	30.9	27.5	1.0	0.7	8	4.0	
13	37.1	0.9	37.8	36.7	0.5	0.7	14	3.6	3.6
14*	35.4	0.5					6	3.8	3.6
15	31.8	0.9	34.5	31.3	0.7	0.7	9	4.6	4.6
16	31.1	0.8	33.9	31.4	1.3	0.8	12	4.0	3.8
17	34.9	0.6	34.6	34.7	0.6	0.6	7	3.0	3.0
18	27.8	0.8	28.6	27.9	1.2	0.5	16	4.2	4.2
19	32.2	1.0	33.9	31.9	1.7	0.9	11	3.8	
20	33.0	1.4	35.8	32.0	1.0	1.0	19	5.0	
21	37.6	1.2	37.2	37.2	0.9	1.1	4	3.0	
22	29.8	1.4	32.4	29.1	1.2	1.4	15	5.2	5.4
23	29.5	1.5	31.7	29.2	1.4	1.1	9	4.6	
24	33.5	1.6	34.7	32.9	0.7	1.6	16	4.4	4.2
25	40.2	1.4	39.5	40.4	1.0	1.1	4	2.2	
26	31.6	1.3	34.6	30.7	0.7	0.9	9	4.0	4.2
27	34.9	0.7	35.2	34.8	0.8	0.5	8	4.0	
28	37.2	0.7	37.5	36.8	1.1	0.6	4	2.2	
29	36.9	0.7	37.9	37.2	1.3	1.1	3	2.6	
30	39.1	1.3	40.9	38.6	1.2	1.2	13	4.6	4.4
31	26.2	1.9	30.8	25.1	1.4	1.8	16	4.0	
32	39.3	0.9	39.4	39.3	0.6	0.9	5	2.4	
**	33.7	1.1					16	4.4	
33	31.8	0.8	32.7	31.9	1.8	0.4	17	4.0	
34	33.9	0.7	35.7	33.9	0.6	0.8	11	3.4	3.6
35	35.6	0.7	35.6	35.4	0.7	0.3	5	2.2	2.0
36	27.2	1.0	29.7	26.8	1.1	1.0	9	4.4	
37	33.4	1.1	35.3	32.8	0.9	1.0	12	4.8	5.2
38	35.8	0.6	37.5	35.6	0.7	0.6	16	3.4	3.2
39	33.7	1.8	36.5	32.7	0.9	1.1	18	4.2	4.4
40	31.1	0.7	32.5	33.4	0.9	1.0	14	4.8	
41	27.8	1.4	29.5	26.9	1.1	1.3	13	4.4	
42	35.7	0.4	36.0	35.8	0.2	0.6	4	2.4	
43	37.6	0.8	38.6	37.5	0.7	0.9	4	2.8	
44	34.9	0.5	35.6	35.0	1.1	0.4	3	2.2	1.6
45	33.4	0.8	34.9	33.3	1.2	0.6	14	4.0	
46	33.0	1.2	35.7	32.4	0.6	0.8	19	5.0	5.2
47	33.1	1.6	35.0	35.4	0.4	1.7	15	5.2	4.2
48	36.7	0.5	37.2	37.0	0.4	0.9	1	2.2	1.8
49	22.8	1.4	22.9	22.1	1.6	1.3	8	4.4	4.2
50***	29.8	0.9					16	5.2	5.4

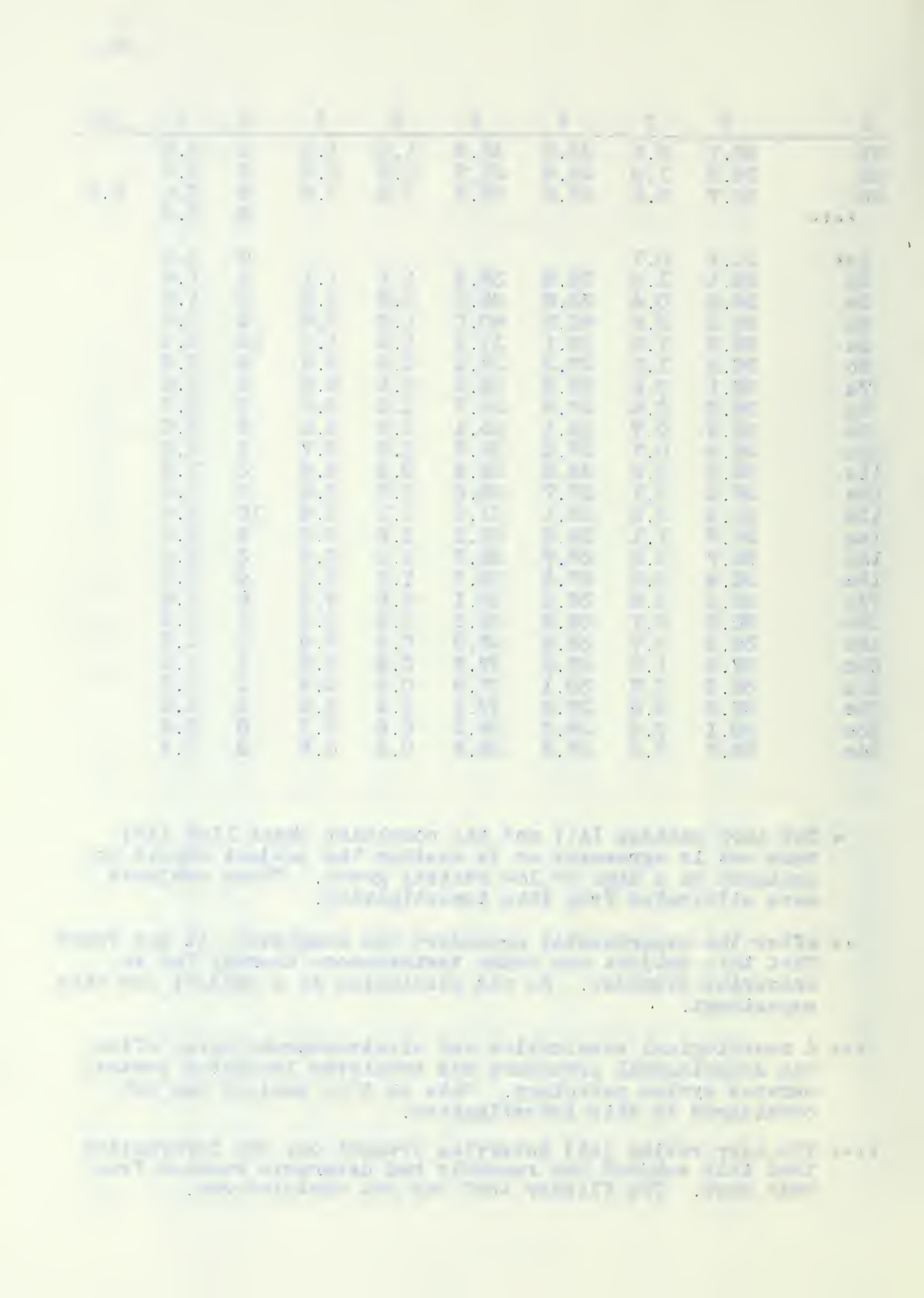
1	2	3	4	5	6	7	8	9	10
51	40.1	0.8	40.2	40.6	1.0	1.0	1	2.2	
52	32.2	1.0	35.4	31.7	0.5	0.4	8	3.8	
53	38.7	0.8	37.8	38.9	0.5	0.6	6	3.0	2.8
****							5	2.4	
1c*	31.7	0.7					6	4.0	
2c	36.1	1.0	36.6	36.4	1.1	1.1	1	1.6	
3c	34.8	0.4	34.6	35.0	0.6	0.5	0	1.8	
4c	40.2	0.9	40.5	40.0	1.0	0.6	3	2.0	
5c	32.5	1.0	34.1	31.9	1.2	1.0	12	3.4	
6c	36.9	1.0	37.3	37.1	0.8	0.8	4	2.4	
7c	36.1	0.5	36.3	35.8	0.1	0.8	3	1.6	
8c	39.6	0.8	37.9	39.7	1.0	0.9	3	1.0	
9c	35.5	0.7	36.1	35.1	0.6	0.5	3	2.0	
10c	38.4	0.7	37.6	38.7	1.8	0.7	1	2.0	
11c	35.0	0.8	34.9	35.4	0.4	0.6	3	1.2	
12c	37.0	0.7	37.7	36.6	0.7	0.5	0	1.2	
13c	31.4	0.6	32.1	31.2	1.1	0.6	10	3.6	
14c	39.7	1.1	38.5	39.1	1.5	0.7	4	2.2	
15c	38.7	0.5	37.7	38.7	1.0	0.4	3	1.8	
16c	36.4	0.9	37.4	36.3	1.6	0.8	4	2.8	
17c	36.5	0.6	37.8	36.1	0.5	0.5	5	2.8	
18c	36.0	0.7	36.6	36.0	0.5	0.3	1	1.6	
19c	36.3	0.7	35.9	35.9	0.3	0.5	0	1.2	
20c	37.9	1.0	37.8	37.7	0.6	0.6	1	1.8	
21c	38.3	0.7	39.1	37.9	0.8	0.9	1	1.0	
22c	37.8	0.6	37.9	37.5	0.4	0.6	0	1.8	
23c	36.1	0.3	36.3	36.2	0.5	0.2	6	2.8	
24c	36.7	0.6	37.5	36.6	0.6	0.5	2	2.4	

* The Lorr ratings (A1) and the complaint check list (A2) were not in agreement as to whether the subject should be assigned to a high or low anxiety group. These subjects were eliminated from this investigation.

** After the experimental procedure was completed, it was found that this subject was under testosterone therapy for an endocrine disorder. He was eliminated as a subject for this experiment.

*** A neurological examination and electroencephalogram after the experimental procedure was completed indicated central nervous system pathology. Data on this subject was not considered in this investigation.

**** The Lorr rating (A1) interview brought out the information that this subject had recently had cataracts removed from both eyes. The flicker test was not administered.



Appendix H

SPECIAL NOTES ON INDIVIDUAL SUBJECTS

The following represents data on individual subjects which are of interest in the investigation of the relationship between anxiety level and flicker fusion measurements:

Subject No. 24: This subject, diagnosed chronic anxiety reaction manifested an auditory accompaniment to his anxiety in the form of a blowing sound. It had been noticed by his psychiatrist that the frequency and intensity of this sound varied directly with his level of anxiety. On the flicker test his "blowing" increased in frequency and intensity as the examination progressed. This phenomenon ran parallel to a progressive reduction in sensitivity to flicker.

Subject No. 2: This subject, diagnosed anxiety reaction, was examined early one morning immediately upon appearing at the clinic. Despite the fact that her scores on the anxiety measures placed her in the high anxiety group, she appeared perfectly relaxed and calm, manifesting none of the overt signs of anxiety. Her FFT (40.2 CPS) was above the mean FFT of the low anxiety groups. In the afternoon, during her psychiatric evaluation, anxiety became manifest in the form of terror and trembling. It

is unfortunate that retest was prevented by a lack of time on the part of the patient.

Subject No. 13: This subject, diagnosed as anxiety reaction, was placed in a high anxiety group by virtue of his scores on the anxiety measures. His FFT (37.1 CPS) was slightly above the mean of the low anxiety groups. After his flicker test the purpose of the study was explained to him and he later reported to his therapist that he hoped he had not spoiled the experiment but that he felt symptom free at the time of examination. His responses to the Lorr ratings (A1) and the complaint check list (A2) were based on recent complaints.

Subject No. 8: This subject, diagnosed as anxiety reaction appeared at the clinic following an unavoidable interruption in psychotherapy during a crisis period, manifesting panic-like anxiety. At this time her FFT was 27.5 CPS. After two months of more intensive treatment, the patient's Lorr rating (A1) dropped from 4.4 to 3.6 indicating a reduction in anxiety level. At this time her FFT was 32.6 CPS, an increase of 5.1 CPS.

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